POWER

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Know the Past

THE development of power from fuel has behind it a history full of romantic interest and strong, engaging personalities. A knowledge of that history is a desirable item in the mental toolbox of a power-plant engineer.

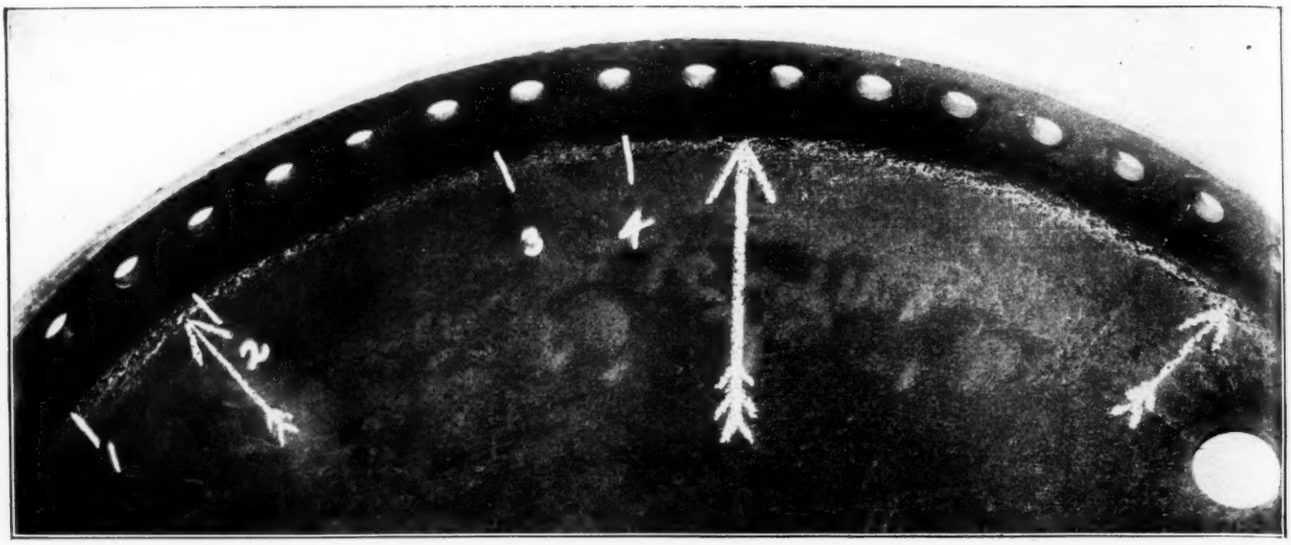
A man is a better member of a craft or profession when he knows its tradition and personnel, the discoveries and inventions that have made it possible and who made them; the struggles that these men went through, the conditions under which they lived, the state in which they found the art and what they did to advance it.

The Corliss engine takes on a new interest when you know something of the life and personality of George Corliss, and the whole day's work takes on a new aspect and significance when viewed against a background of history and tradition and fundamental principles.

It is well to be up to date, to live in the present with one's face to the rising rather than the setting sun, but no one can appreciate intelligently the present state of an art who is ignorant of its past, and there is nothing better than a knowledge of what has been done to indicate the lines of possible progress and to furnish the suggestion and incentive and inspiration to further accomplishment.

The libraries are full of biographies of men who have made the heat engine what it is and unfolded its underlying principles. Learn to know them better—not as they sat for their portraits—but in their working clothes.

F. R. Low



A Near Boiler Explosion

Leakage Near Flange of Bumped Head Led to Investigation Which Disclosed Dangerous Crack—Breathing of Head Probable Cause

By G. W. ATKINSON*

THAT those employed in a power plant do not always realize impending danger was emphasized last summer in one of the boiler plants at the Springfield Armory. The boiler was one of a battery of four and was of the horizontal water-tube type, operating normally on 150 lb. gage. They had been installed new in 1913 and had been given excellent care; in fact, the city water used for boiler feed was practically free from sediment or unusual hardness and formed only a slight corrosive covering. The working pressure for which they were originally designed was 175 lb. The heads were of $\frac{7}{16}$-in. metal and the drums 42 in. in diameter.

A slight leakage of steam was noticed a few inches below the water line near the rivet edge on the rear head of a steam drum. Upon close examination it was found that the steam leakage was practically at right angles to the surface of the boiler plate and occurring on the convex portion of the small radius of the bumped head. External examination revealed no particular defect, and it was assumed that a pin-hole leak due to a flaw in the metal had opened up and this could be readily repaired by drilling, tapping and plugging. The boiler had been officially inspected four months prior and passed as being in first-class condition both internally and externally, and proved to be free from leaks at 225 lb. hydrostatic test.

The boiler was let out of service for repair, and upon close internal examination, it was discovered that instead of a small pin-hole defect at the leak, there existed a crack about 20 in. long on the inner side of the acute radius, as indicated in the photograph. The severe portion of the crack existed in the vicinity of the large arrow, where for a distance of 6 in., a knife-blade could be easily inserted for a depth of $\frac{1}{8}$ in.

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The matter was immediately given close consideration and referred to the manufacturers for explanation. Their report in part is as follows:

> It is our opinion that the crack is due to the constant weaving of the boiler head when the boiler is in operation. It has been proved that when a boiler is in operation, a dished head which is not braced, has a movement similar to the movement that takes place in breathing and this continued movement of the plate in the head has caused it to crack. . . . During the last five or six years there has been a tendency on the part of boiler manufacturers to increase the thickness of the dished heads, and we would recommend that in this particular case you replace the head with a new one of heavier material.

It was not considered advisable to repair this head by welding with either the electrical or acetylene process. It was replaced by a new head $\frac{13}{16}$-in. thick, as recommended by the manufacturers. After the old head had been removed, it was passed to the metallurgical laboratory at the armory for examination, which disclosed the following results:

Distortion Investigated

About 4 in. of the crack, in the vicinity of the large arrow, extended entirely through the metal except for a skin covering on the external surface. A plaster-cast form was taken of the inner radius of the rupture and one diametrically opposite where the metal was in perfect condition. These casts permitted the drawing of curves which represented the exact radius and shape of the internal surface. The inner curve was formed on a true arc having a radius of $1\frac{1}{2}$ in. That on the perfect section followed the true arc, while the defective section showed a variance of $\frac{1}{32}$ in. at two places which formed a compound curvature in the vicinity of the crack. Although the comparison showed the two curves to be somewhat dissimilar, there was not sufficient evidence to assign the entire effect of failure to an improperly shaped curve.

The chemical composition was determined from samples that were taken at points marked 3 and 4 in the photograph reproduced at the top of the preceding page.

Carbon	0.25 0.26	Manganese	0.41 0.43	Sulphur	0.037 0.039	Phosphorus	0.014 0.014

Two tensile specimens taken close to the crack and parallel with it near the locality of the center arrow in the photograph gave the following results:

Yield point	42,600 42,700	lb. per sq. in. " " " "
Tensile strength	64,050 64,100	" " " " " " " "
Elongation in 2 inches	32.5 31.5	per cent per cent
Contraction of area	54.3 55.9	per cent per cent

A number of pieces were take. from similar positions to those marked 1, 2, 3, 4. All showed excellent ductility and a good fracture when broken by blows from a hammer. This was true whether they were from the ruptured section or elsewhere.

Microscopic examination was made, using samples cut from the shell at places marked 1, 2, 3, 4 and another, not shown, taken similarly but diametrically opposite 4. In all these specimens the structure is similar and characteristic. Non-metallic inclusions were few and well distributed.

Material Not to Blame

The cracking evidently was not due to poor quality of material, although there was some evidence that it did not receive the best of mechanical treatment at the time of manufacture. On the inner surface, where the radius of curvature is least, there were many hammer marks. (They are not to be confused with those caused when the head was removed from the boiler, which are more noticeable.) The effect of these on the structure of the material is shown in Fig. 1. This represents a section normal to the surface located at 3 (photograph on preceding page). Fig. 2 is the same sample after annealing and is shown for purposes of comparison with that in Fig. 1.

Low-carbon steel such as that under consideration is made up of an aggregate of particles or so-called grains of ferrite and pearlite. When etched with dilute acid and examined under the microscope, the pearlite grains appear dark and the ferrite white. As the metal slowly cools from above the critical temperature range, these particles or grains assume, ordinarily, the shape shown in Fig. 2, which is typical of a low-carbon annealed steel. If, however, it is deformed cold by bending, hammering, etc., the grains become distorted, as shown in Fig. 1, particularly near the right-hand edge. This condition, unless it has been carried to extremes, can be removed by annealing, as can readily be seen by comparing Figs. 1 and 2. It might be added that not only is the appearance of the metal under the microscope altered, but its physical characteristics as well are changed.

Cold Stresses Contributory

An effect of the cold work illustrated is to set up internal stresses in the metal and also to reduce the ductility. It is not believed that these effects were sufficient to account for the failure, but it is probable that they contributed by localizing the strains produced by the weaving action of the head when in service. The crack, having once started, would still further localize the effect caused by outside forces and would readily be extended under a continuation of the conditions that originally produced it.

The sides of the crack were much corroded; this having removed any metal which may have been distorted by the alternate bending or weaving that caused the crack. The extent of this motion was probably not great, perhaps only sufficient to but slightly exceed the elastic limit, and would leave little evidence in any case. The area between the bottom of the crack and the outer surface of the head did show distortion of the structure under the microscope in those samples in which the crack extended nearly through.

In general, the material was suitable for the purpose for which it was used. In the course of manufacture it was subjected to a mechanical treatment that probably contributed to and accelerated the cracking. This seems to have been caused, principally, by neglect to use a design which provided a sufficient margin between the stresses to be met and the elastic limit of the steel used.

[The condition described by Mr. Atkinson has been the cause of several disastrous explosions during the past ten or fifteen years. While present practice provides for thicker heads, there are nevertheless many of the older boilers still in service and this part of the drum should receive especially close attention.—Editor.]

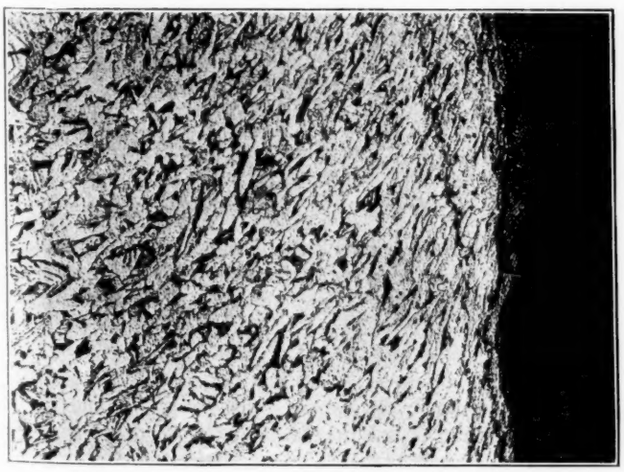


FIG. 1. SECTION NORMAL TO SURFACE BEFORE ANNEALING

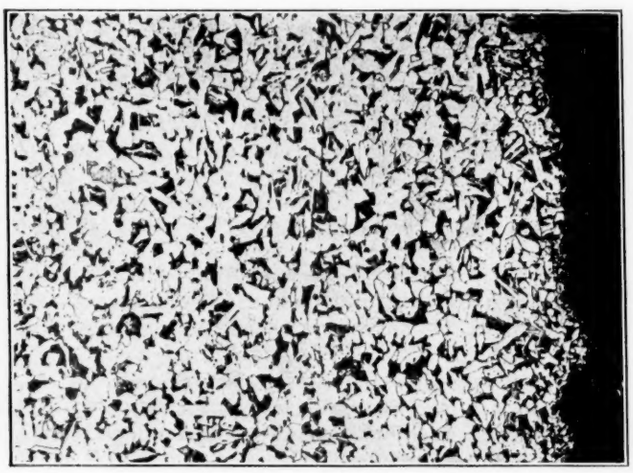


FIG. 2. SAMPLE SHOWN IN FIG. 1 AFTER HAVING BEEN ANNEALED

Types and Constructions of Ammonia Condensers

A Discussion of the Principles of Operation of the Several Condensers in General Use

AMMONIA condensers may be divided into four general classes, depending upon the arrangement of the cooling surface, and manner of the flow of cooling water and the ammonia. Many new and special designs of condensers have been brought out in the last few years; this is especially true of the atmospheric type. In this type the water is led in an open flow over a vertical coil of pipe. It is exposed to the atmosphere as it flows over the coils, thus the name atmospheric may be well applied. The double-pipe condenser, as the name implies, is made up by inserting one pipe within another. The water flows through the internal pipe, and the ammonia through the annular space between the pipes. Surface condensers have been developed by trying to design an ammonia condenser that would be similar to the steam condenser. The shell and tube condenser is an example of this type. The ammonia is condensed in the shell by water flowing through the tubes that extend from head to head. Another type may also be made up with a shell for holding the condensing ammonia and a series of spiral coils for the cooling water. The submerged type, as the name implies, is constructed by simply submerging an ammonia coil in water. This type is practically obsolete at present and is used only on very small plants. The following outline will indicate these various types of condensers.

Class I: Atmospheric Condensers. Type A, Standard atmospheric; Type B, Bleeder; Type C, Flooded; Type D, Preliminary Hot Gas Cooler; Type E, Preliminary Hot Gas Cooler with Liquid Cooler.

Class II: Double-Pipe Condensers. Type A, Standard Double Pipe; Type B, Bleeder Double Pipe.

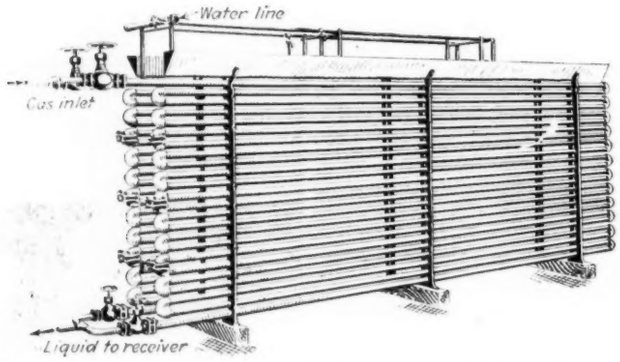


FIG. 1. STANDARD ATMOSPHERIC CONDENSER

Class III: Surface Condensers. Type A, Shell and Tube; Type B, Shell and Coil.

Class IV: Submerged Condensers. Type A, Tank and Spiral Coil; Type B, Tank and Flat Coil.

This list is probably incomplete, but it contains those that are considered standard, together with several that may be considered as special. The standard atmospheric, the bleeder atmospheric and the standard double-pipe condensers are the types that are used principally at present.

The standard atmospheric ammonia condenser is in the form of a flat vertical coil and usually is made up of sixteen to twenty-four pipes each 20 ft. long and 2 in. in diameter. These pipes are connected on the ends by either split or flanged return bends, putting the pipes on 3½-in. to 4½-in. centers. The coils are supported by three cast-iron stands and are placed on about 20-in.

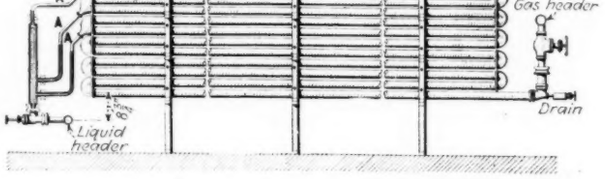


FIG. 2. BLEEDER-TYPE ATMOSPHERIC CONDENSER

centers to allow sufficient passageway between them for cleaning and inspection purposes, and are connected by means of individual valves to suitable gas, liquid and pump-out headers, as shown in Fig. 1.

The cooling water is distributed over the coil surface by means of a galvanized V trough or a slotted pipe over each coil. The trough supports are adjustable for the purpose of elevating the trough so as to obtain an even distribution of water over the coil surface.

The hot ammonia gas from the compressor enters the coils through the gas-inlet header at the top of the condenser and flows downward through the piping until it reaches the bottom. The water flows downward over the outside of the coil. The ammonia condenses as it flows along the pipes, and by the time it reaches the bottom the liquefaction has been completed. The water and ammonia flow in the same direction. There is no countercurrent effect, but, owing to liberal allowance of coil surface and condenser water, this type of condenser really performs its functions in a satisfactory manner. Of course, in the dryer localities, the evaporation of some of the water in passing over the exposed coils aids the cooling of the ammonia quite appreciably. It is evident that the liquid leaving the condenser cannot be cooled to the lowest possible temperature, since it is at least as warm as the water leaving the condenser after condensing the ammonia.

The Bleeder-Type Ammonia Condenser

The bleeder-type ammonia condenser, as illustrated by Fig. 2, is quite similar in general design and construction to the standard atmospheric condenser just described. This type is generally twelve pipes high, and every fourth pipe has a small drainage oulet *A* by means of which the liquefied ammonia is drained off and carried down directly to the main liquid header. The gas-inlet header is connected to the bottom of each coil instead of into the top. The coils are connected to a pump-out header by means of individual valves for each section.

The cooling water flows downward over the outside of the coil, and the hot gas from the compressor, being introduced at the bottom, flows upward, thus giving the countercurrent effect. The vapor is condensed as it ascends the coils, and the liquid is drained off at once through the outlets on the return bends, flowing through the bleeder connections to the liquid header and from there to the liquid receiver. By this method the liquid ammonia is continually drained from the condenser, leaving the condensing surface free from the accumulation of liquid that occurs in the standard type of condenser. This is a great advantage, because it allows more of the condenser surface to be available for liquefying the ammonia.

Upon further inspection of this type of condenser, it will be observed that the temperature of the liquid ammonia will be near the temperature of the water at the point where it is drained off. In fact the temperature of all the liquid in the liquid header will be quite near the temperature of the water at its inlet.

Flooded Atmospheric Condenser

Fig. 3 illustrates the general construction of the flooded atmospheric condenser. The coil itself is constructed by means of pipe and return bends as in the usual atmospheric condenser, and is generally 16 to 20 pipes high. The cooling water is distributed over the coil by a trough or slotted pipe. The hot gas is introduced at the bottom through the line *A*, and the liquid is withdrawn from the top into the header *B* as shown.

By reference to the drawing it will be noted that a connection *C* is made by which a regulated amount of cool ammonia liquid is injected into the condenser with the hot gas from the inlet line *A* by means of a flanged

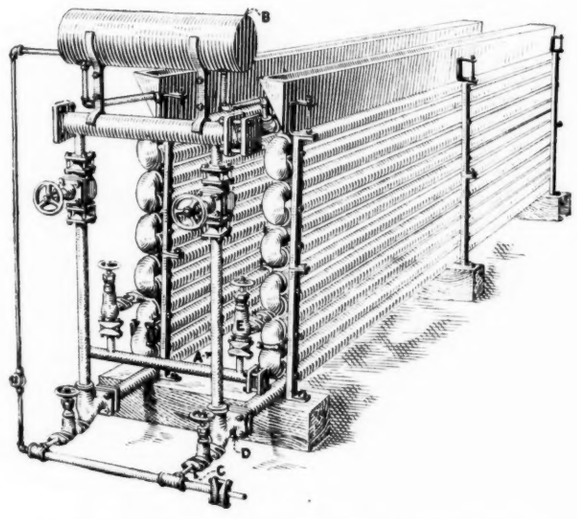


FIG. 3. FLOODED ATMOSPHERIC CONDENSER

nozzle *D*. The nozzle is similar to the nozzle of an injector and discharges the mixture of gas and liquid into the lower pipe of the condenser at a high velocity, which will carry the gas and liquid to the top of the condenser. This arrangement produces a mixture of vapor and liquid in the lower part of the condenser and allows the vapor to be all condensed before it reaches the top of the condenser. The liquid is collected by the liquid header *B* and is taken to the liquid receiver by suitable piping. By means of a special return bend *E* on the fourth and fifth pipes from the bottom, it is possible to admit hot gas above the lower pipes, which under certain conditions may be found advantageous.

The arrangement gives the countercurrent effect, which producers liquid ammonia that is near the temperature of the cooling water at the inlet. The gaseous ammonia, in rising through the condenser, changes from

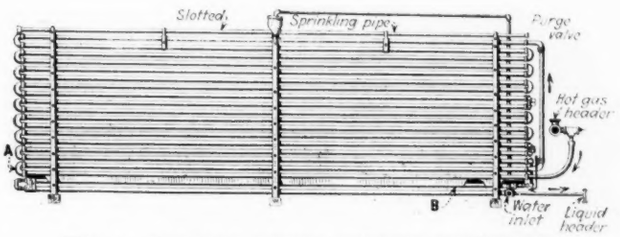


FIG. 4. GAS AND LIQUID COOLER CONDENSER

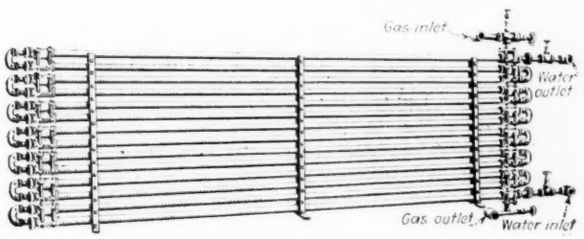


FIG. 5. DOUBLE-PIPE CONDENSER

a vapor to a liquid state and tends to flow back through the coils by gravity. The descent is opposed by a strongly rising current of gas and liquid from the injector nozzles *E* and *D*, producing great agitation of the mixture. The exterior surface of all the globules of gas, which are surrounded by cool liquid ammonia, presents a very much increased condensing surface. For this reason and because of the fact that heat transfer from liquid through metal to liquid is very good, this type of condenser has a much larger capacity than other condensers of the same size.

Atmospheric Condenser with Hot Gas Cooler

An atmospheric condenser that has a preliminary hot-gas cooler section at the bottom is sometimes used. In all other respects the construction is the same as the standard atmospheric condenser. The hot gas from the compressor passes through the lower section first, before being delivered to the upper part of the condenser. The purpose of this preliminary section is to utilize the warm water to cool the hot gas to the saturation point before it comes in contact with the colder condensing water at the top. The hot-gas section is, of course, provided with a drain and trap for conveying any ammonia that may be condensed to the liquid header. This type of condenser will cool the liquid somewhat lower than will the standard type of atmospheric condenser.

Gas and Liquid Cooler Condenser

An atmospheric condenser with a preliminary hot gas cooler and a liquid aftercooler section as illustrated in Fig. 4 is frequently used under certain conditions. This condenser, otherwise, is similar to the standard type. The hot gas from the compressor is led through a preliminary cooling section *A* which removes some of the superheat. The vapor now goes to the top of the condenser to be liquefied. After liquefaction the liquid goes through the double-pipe aftercooling section *B*. The

condensing water is passed through the aftercooler first and then allowed to descend over the condenser.

The principal advantage of this arrangement is that the liquid ammonia is cooled to near the temperature of the inlet condensing water. This type, of course, must be considered more or less special.

Double-Pipe Condensers

The double-pipe type condenser is used quite extensively. This condenser, which is illustrated in Fig. 5, is

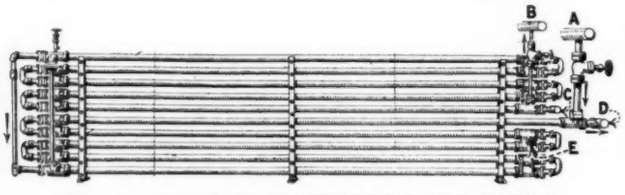


FIG. 6. FLOODED DOUBLE-PIPE CONDENSER

generally made up of 1¼-in. water and 2-in. ammonia pipes placed one within the other. The inner pipes connected at the ends by the usual double-pipe return bends and solid return bends inclose the water-circulation system. The space between the two pipes forms passages for the ammonia.

The water and ammonia flow in opposite directions; thus the condenser operates on the countercurrent principle. The water enters at the bottom and passes upward through the 1¼-in. pipes. The ammonia enters at the top and passes downward through the annular spaces between the pipes, leaving as liquid at the bottom.

Thus the hottest gas meets the warmest water, and during its descent and liquefaction it becomes cooler and meets the coldest water. The ammonia liquid is cooled very near the temperature of the water at the inlet. The heat transfer between the water and the ammonia is good, which results in efficient operation. Also the condenser is economical in the use of water.

Flooded Double-Pipe Condenser

Fig. 6 shows the construction of a double-pipe condenser operating on the flooded principle. The hot gas from the gas-inlet header *A* flows downward through the annular spaces between the pipes in the lower part of the coil. After reaching the end of the lowest pipe, it is bypassed to the top pipe and then travels downward again through the upper portion of the coil to the liquid outlet *B*. The water, entering at *C*, flows in the opposite direction and leaves at *D*, which gives the advantages of the countercurrent operation.

In order to make the different coils operate evenly and to avoid the constant attention of the operating engineer, an ammonia regulating valve *E*, as indicated in the illustration, is introduced in one of the ammonia return bends. This valve is generally kept open ¾ to 1½ turns.

Surface Condensers

A horizontal shell and tube condenser is used only under special conditions. This type of condenser is made up with a horizontal steel shell with heavy steel heads and a large number of extra-heavy charcoal tubes that extend from head to head. The water circulation is inclosed by means of baffled heads bolted to the shell at each end. These heads cause the water to traverse the length of the condenser ten to twelve times, passing, of course, through the tubes. The ammonia is retained by the shell, and after liquefaction it is drained off at the bottom of the shell.

The type of condenser may also be arranged in a vertical position, in which case the water passes downward through the tubes and is then discharged to the sewer. In this arrangement cores are sometimes inserted into the tubes to give water a higher velocity.

This type of condenser has the disadvantage of leaks forming at the joints between the heads and the tubes.

Likewise the vertical shell and spiral-coil condenser is used only under special conditions shown at Fig. 7. The vertical shell contains the vapor which is introduced at the top through the central pipe and drained off as liquid at the bottom outlet. The cooling is accomplished by a series of spiral coils of pipes that are inserted into the shell. These coils pass through stuffing boxes in the heads and are attached to inlet and outlet water headers. This type of condenser, of course, has the disadvantage of being difficult to clean should the water deposit scale or other matter on the coils.

The surface condenser for ammonia has, no doubt, been created by attempts to design a condenser that would be similar to the steam condenser.

Submerged Condensers

The submerged ammonia condenser is constructed by simply placing a coil of pipe in a tank filled with slowly moving water. These may be made in the manner of a tank with spiral coils or a tank with plain flat coils. The gas enters the top of the coil and is drained off at the bottom at liquid. The water is admitted at the bottom and overflows near the top. The circulation of

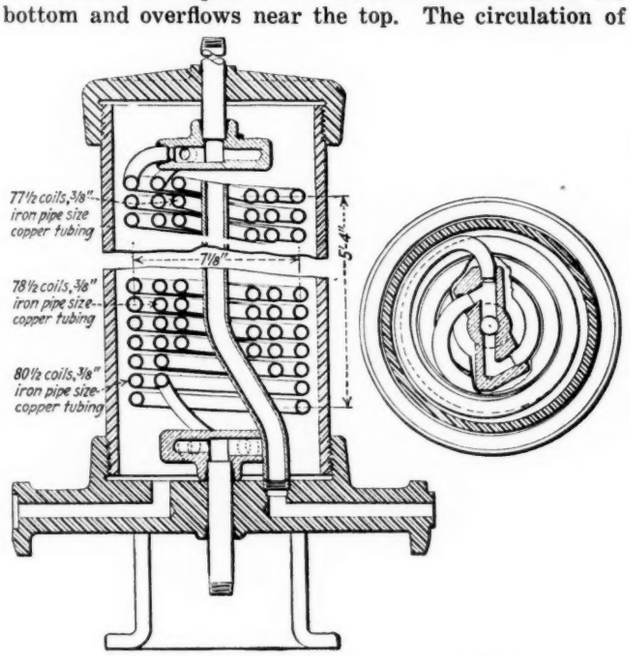

77½ coils, ⅜" iron pipe size copper tubing
78½ coils, ⅜" iron pipe size copper tubing
80½ coils, ⅜" iron pipe size copper tubing
7⅛"
5'-4"

FIG. 7. SPIRAL-COIL CONDENSER

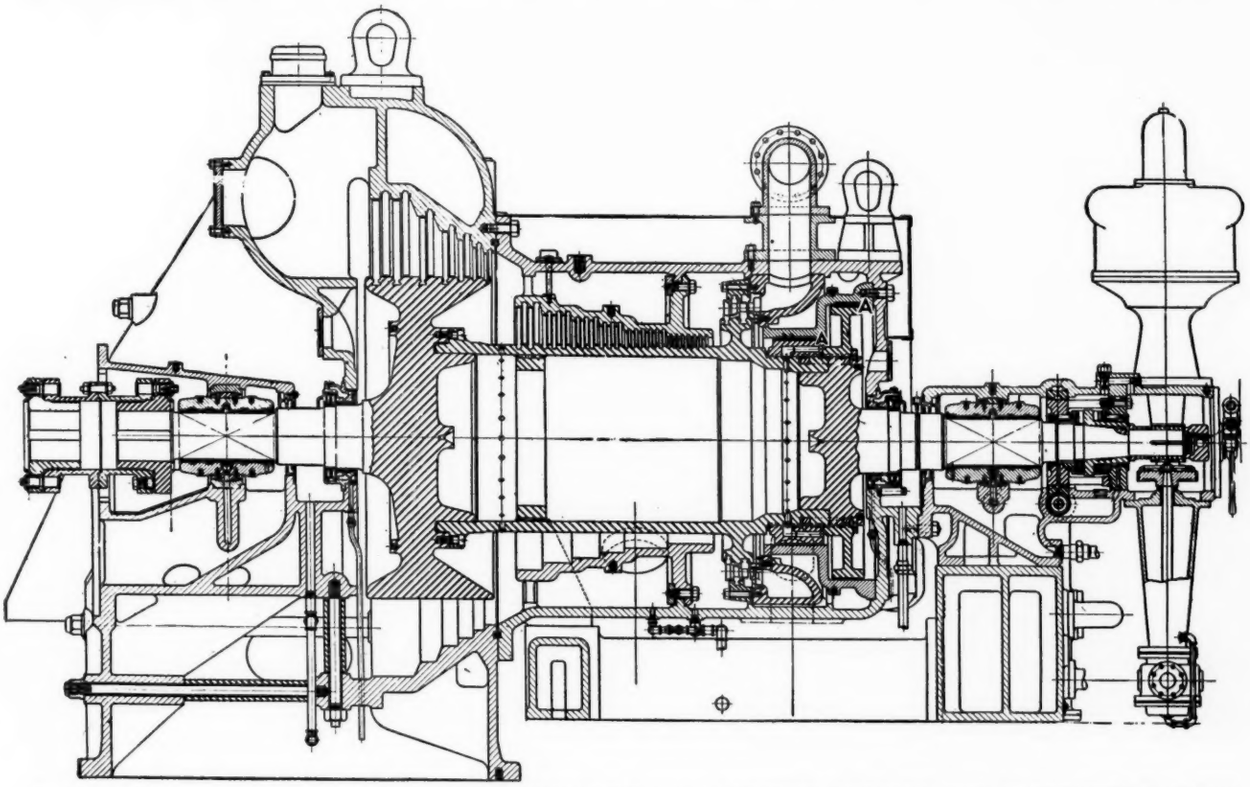
the water over the coils is, of course, very poor, and this is sometimes improved by inserting revolving paddles or other stirring devices into the water. The circulation of the water in the flat-coil type is also poor, and this may be improved somewhat by using slotted pipes for distributing the water evenly.

From the foregoing considerations it will be appreciated that there are numerous ways of arranging the condenser surfaces, and that the arrangement will effect the efficiency of the service of the condenser as a cooling, liquefying and aftercooling apparatus.

Failure of Labyrinth Packing Shuts Down Turbine

On Dec. 22, 1921, an accident occurred at the Des Moines Electric Co.'s plant on a 12,500-kva. single-flow combination type steam-turbine unit. The turbine had been installed recently and was undergoing preliminary operation at the time of the failure.

On the day of the accident the turbine had been started up at 6 a.m. and approximately half an hour was employed in getting it under way. It then operated for some twenty minutes with a load not exceeding 2,500 kw. The operating engineer believed it to be working satisfactorily and proceeded to perform some duties at the switchboard. While he was there, the lights became dim and this was followed by an unusual noise, apparently emanating from the turbine. The machine was taken off the line, shut down and was immediately dismantled in order to determine what was wrong.



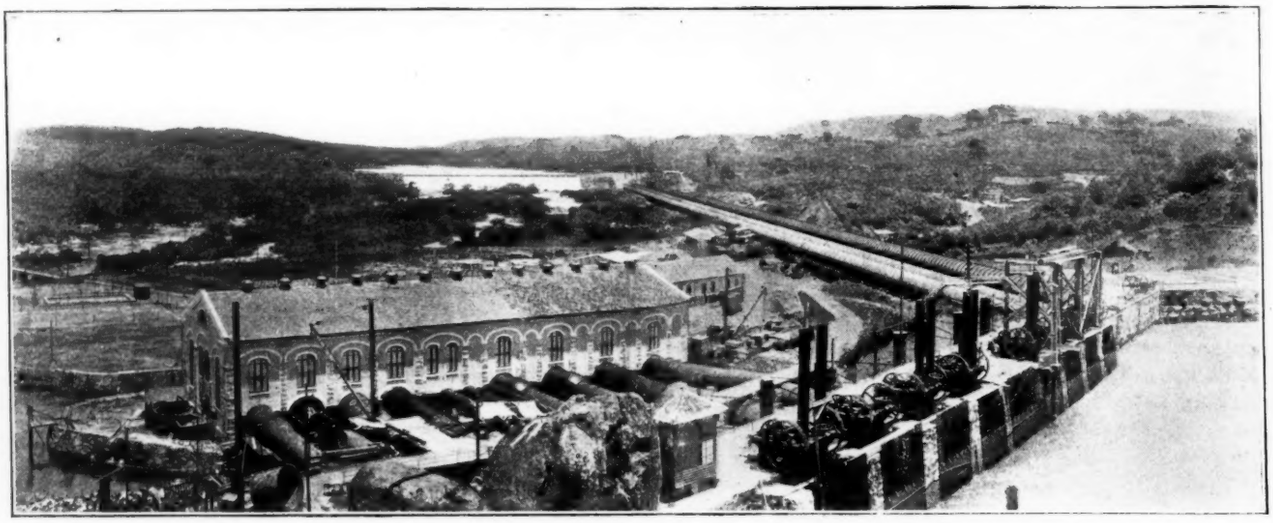
CROSS-SECTION THROUGH SINGLE-FLOW COMBINATION TYPE TURBINE, SHOWING THE LABYRINTH PACKING

A cross-section of this turbine is illustrated herewith. The high-pressure steam expands through nozzles to a two-velocity stage impulse element, the remainder of the expansion being carried out by means of reaction elements. The turbine being single-flow, the end thrust incidental to the pressure of the steam on the turbine elements is partly balanced by means of labyrinth packing *A*, the remainder of the thrust being taken by a thrust bearing shown at the extreme end of the machine.

On dismantling it was found that the smaller of the two diameters of labyrinth packing had become injured, resulting in a tremendous amount of heat being generated, which caused the revolving portion to become loose on the spindle. It probably had been red hot. This in turn caused the breaking of the stationary portion of this labyrinth packing. The exact cause of the trouble is not easily determined, beyond the fact that the stationary and rotating strips came in contact with one another sufficiently to generate heat, which in turn precipitated the accident. The vibration was so severe at the time of the disturbance that the pedestal carrying the turbine governor was broken. This vibration also caused some minor injuries to the blading.

It was at first thought that the accident might have been due to maladjustment or to some abnormal distortion incidental to warming of the machine before starting. However, when the turbine spindle was returned to the manufacturer and taken apart, it was found the shrink links which hold the elements of the spindle body together did not fit down solidly on the body of the spindle at the time they were turned for the fit of the revolving labyrinth packing rings. This was evidenced by the chafed condition of the shrink links and the corresponding bores of the rings on which is carried the labyrinth packing. The trouble having been more severe in the smaller of the two rings would seem to point to the possibility of there having been a hidden flaw in this portion. It had been injured, however, to such an extent that no definite determination of this could be made.

The construction of the machine, fortunately, is such that both the stationary and moving parts of this labyrinth packing may be readily replaced, so that not more than four weeks' loss of service was involved.



VIEW OF PARNAHYBA HYDRO-ELECTRIC PLANT AS IT APPEARED WHEN COMPLETED

Increasing Capacity of Parnahyba Plant

How a Hydro-Electric Plant, Originally Laid Out for 16,000 Horsepower Was Modified to Develop Double This Capacity

BY H. P. QUICK*

PRESENT interest in hydro-electric development is not alone in the construction of new plants, but also in methods to increase the capacity of systems already developed. The development referred to in this article is not a new one, but so many possibilities of increasing the capacity of hydro-electric plants are illustrated in its final construction as to make it of interest at this time. In the district served by this plant demands for power increased so that the original arrangements to install eight 2,000-hp. units had to be modified until the system contained eight 4,000-hp. machines. However, in the final plant the first four 2,000-hp. generators were arranged to be used as 4,000-hp. units by grouping them in pairs. Increased capacity was obtained without enlarging the forebay or making any change in the penstocks, gates or racks.

About 23 years ago a group of Canadian capitalists and American engineers under the leadership of the late Dr. F. S. Pearson, the noted pioneer American electrical engineer, began hydro-electric development in South America to supply power for local tramways and light and power distribution in the City of Sao Paulo, Brazil, at that time a commercial metropolis of about 250,000 inhabitants. The first plant was built at Parnahyba. on the Tiete River, about 20 miles from Sao Paulo, and was one of the first of the kind in South America. From the records of river flow over a number of years, available at the time the project was started, there seemed to be ample water for at least 10,000-kw. output for 10 hours a day during the year. However, it developed later that without greater storage capacity than first provided, this was not possible as a continuous output. The future possible demand, as far as could be seen, required the plant to be laid out for eight 2,000-hp. units, but the first section of the power house was built only for four units with two waterwheel-driven exciters at one end.

The site selected for development was a series of rapids having about 39-ft. fall. These were dammed up to double the head, or about 78 ft. Two 12-ft. steel feeder pipes, shown on the right in Fig. 1, also in the headpiece, were run to the forebay, made by damming up a small recess between two low hills. From this forebay four 8-ft. steel penstocks with 10-ft. bell-mouths were taken out and extended 210 ft. to the power house, with draft tubes dropping into a masonry tailrace. This tailrace was between the power house and forebay, directly under the turbines, which were located outside the power house. The turbines were of the horizontal type with double inflow and central outflow, of two or three different American makes, having enlarged casing and cylindrical gates. The turbine shafts projected into the power house and were coupled to horizontal-shaft generators, rated at 1,000-kw. normal and 1,400-kw. maximum capacity and generated 2,300-volt current, which was stepped up to 22,000 and 24,000 volts.

Before the plant had been in operation many years, the demands for power and light were increasing so rapidly that it became imperative that something be done besides placing additional units in an extension to the power house. An extension had already been built before 1905 for two more machines, and one had been installed and was ready for operation at that time. This unit was made double the size of the first four because it was found that this capacity could be placed in practically the same space and needed no larger penstock, owing to improvements in design and efficiency, especially foreign turbines such as the Swiss wheels. These were also much cheaper delivered in Brazil, therefore were used. With the additional draft on the forebay it was now necessary, in order to maintain the head on the wheels, to raise the height of the dam at the reservoir shown at the upper end of the pipe lines in the headpiece This was done by building a permanent

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concrete flashboard over the spillway to a height of one meter (3.28 ft.). To take care of the discharge from the new units, it was necessary to build a new tailrace by carrying their draft tubes under the power house to a canal on the other side.

About 1906 the question of additional storage capacity was deemed serious enough for study, and outside engineering experts in the construction of large earth dams were sent down to Brazil to investigate and report.

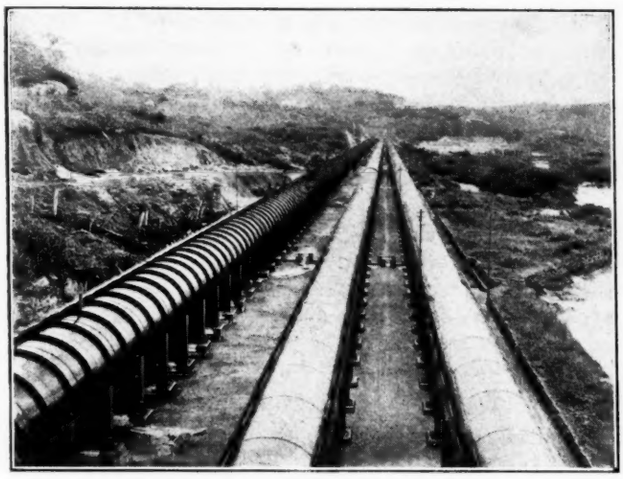

FIG. 1. LOOKING FROM RESERVOIR TOWARD FOREBAY ALONG PIPE LINES

After studying the various sites, it was recommended to build a large reservoir on the Rio Guarapiranga, one of the large branches of the Tiete river. The original reservoir, shown at the upper end of the pipe lines in the headpiece, was rather small and was continually getting clogged up with tropical vegetation, floating islands, etc., which seriously reduced its capacity. In fact, when the writer saw it at a later period, its surface was absolutely invisible so dense was the growth. There is not much that can be done with this material except to push it over the dam or drag it up into the narrow inlets at the side of the reservoir.

The new reservoir is one of the largest in existence and impounds a lake of 195,000,000 cu.m., or 157,950 acre-feet capacity. This reservoir, which was completed in 1908, enabled the plant to carry not only a higher peak, but an increased continuous 10- or 12-hour load throughout practically the whole year.

By the time the reservoir was completed, another 4,000-hp. unit had been installed, and plans were under way for a further extension to the plant to contain two more units which the new reservoir had made possible. The plant had now outgrown the capacity of the two pipe lines between the original reservoir and the forebay, so that a 15-ft. feeder (shown on the left, Fig. 1) was constructed. Before this work was completed, Nos. 7 and 8 units had been installed, one in 1909 and one in 1911, making four 4,000-hp. units in addition to the original four 2,000-hp. machines.

These large feeders, unlike canals which are frequently used in their stead and which were here impracticable, have to have many special features such as expansion joints, stiffening ribs, cradles, sand traps, waste gates, air events, etc. They have to be shipped knocked down in small sheets. It is worthy of note that while the two original feeders had to have American erectors sent down to construct them, the third and largest, with hundreds of stiffening angles, was erected entirely by native labor under supervision of the power company's engineers.

Power requirements in 1910 were so great that even with these improvements the demands could not be supplied with the storage available during 14 hours of the day. A reserve steam plant had to be built and was located near Sao Paulo city substation. This plant contains two 2,000-kw. steam turbo-generators with jet condensers. By using this plant to help out on the peak loads so that head could be maintained near maximum at the hydro-electric plant, and by using the steam plant extensively during low-water periods, water was found available for a further and final increase in the plant. This was done by building over the four original units into the same size and type of the last four installed, namely, 4,000-hp. turbines with wicket gates. How this was done from the waterwheel end with but a slight enlargement of the original casings and using the same penstocks as for half the power, was a triumph of hydraulic turbine engineering progress. Much credit is due to Louis J. Hirt, of New York, chief engineer for the Pearson Engineering Corp., in the design of the wicket gates and turbine-runner passages, and in using the increased natural and velocity heads obtained by methods before mentioned to obtain double capacity.

On the generator end there were the four old 2,000-hp. generators of half the power of the new wheels, and it was found that by combining them in pairs as shown in the foreground, Fig. 2, it would only be necessary to get two new generators. In combining them, however, two new shaft extensions and special base castings were required. These machines were mounted the same as

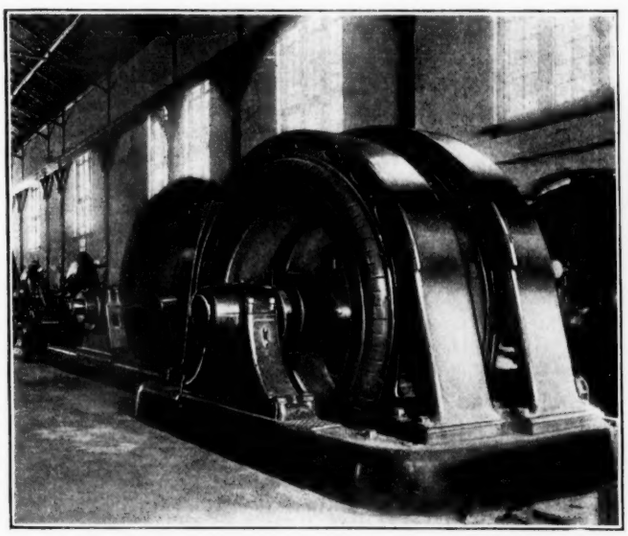

FIG. 2. TWO 2,000-HP. GENERATORS COMBINED TO MAKE ONE UNIT

one machine with only two bearing pedestals and made a very compact and satisfactory arrangement. To the exciting equipment there was also added a motor-generator exciter and one turbo-exciter equipped to operate with a motor or turbine interchangeably. All these extensions required radical electrical changes and enlargements, which with the installation of the 20,000-volt underground system in Sao Paulo and the testing and operation, were supervised by the electrical engineer, Dr. Edouard De Souza, a native Brazilian who has grown up with the system since it began in 1900.

Precautions in Storage-Battery Operation

By CHESTER SCHENCK*

A STORAGE battery such as is installed in a modern power house or substation to furnish direct current for opening and closing electrically operated oil switches, needs relatively little attention if it is given properly and at the right time. The kind of care, however, is different from that required by other forms of equipment. Because the maintenance of the battery is only a small part of the responsibility of the employee to whom it is intrusted, he is liable to underrate its importance and, by performing his duties hastily and carelessly, cause injury to the battery or to himself before he is aware of the danger.

As the small size of the battery room limits the freedom of movement to which one is accustomed, and no strenuous labor is required, it is well for the storage-battery attendant to form the habit of curbing his usual activity while there. A few simple precautions will then do much to prevent serious consequences.

It is best to heed the familiar "No Smoking" sign. Hydrogen gas is given off by the cells at all times, and in much larger quantities while the battery is being charged. The mixture of gas and air formed is highly explosive when ignited. Do not smoke, light matches or bring an open flame such as a lighted torch or plumber's pot into the battery room. Avoid making or breaking electrical connections that may cause a spark or draw an arc. Use a flash-light or an extension cord if more light is needed.

Cleanliness Essential in Battery Room

Keep the battery room as well ventilated as possible while the battery is being charged, to remove the explosive gases as liberated and to prevent the accumulation of the corrosive fumes of sulphuric acid. These fumes result from the fine spray of acid thrown into the air by the breaking of the bubbles of gas as they escape from the surface of the electrolyte. This does not mean, however, to leave the battery-room door open so that the acid fumes fill the whole station, to the annoyance of the eyes and lungs of attendants and possible injury to metal parts of delicate instruments.

Orderly methods are essential. Maintain a condition of absolute cleanliness in the battery room. Keep the electrolyte and distilled water clean. Fill the cells with distilled water often enough to hold a fairly constant level of electrolyte and to make certain that the tops of the plates never become exposed to the air.

Breaking of cell jars, pitchers used for filling the cells, distilled-water bottles, acid carboys and other glass containers must be guarded against. Be careful not to break the hydrometers and special thermometers; they are somewhat expensive to replace, and usually a long time elapses before new ones are provided.

The battery must not be discharged to low limits of voltage and specific gravity, under normal conditions, but if it is absolutely necessary to do so in an emergency, start charging immediately and continue until the charge is complete. Do not let the battery stand in a discharged condition.

There is a limit of temperature, usually around 100 deg. F., which can be obtained from the operating instructions furnished by the manufacturer, and which should never be exceeded at any time. If the battery is being charged, reduce the charge rate or discontinue the charge temporarily until the cells cool off.

When working around the battery, be careful not to accidentally short-circuit one or more cells or the entire battery. It injures the battery, and a considerable part of the stored energy can be delivered instantly into a short-circuit, so that one is almost sure to be burned by the resulting flash or by flying particles of hot metal.

Never pour water into sulphuric acid when mixing electrolyte; pour the acid slowly and carefully into the water instead. Do not add acid of greater than the normal specific gravity of the cells directly to the cells, and unless the attendant is thoroughly experienced, it is best for him to consult the foreman, chief engineer or superintendent before doing this. Do not mistake lightning-arrester electrolyte for storage battery electrolyte under any circumstances; it is not at all suitable.

Making Inspection of Cells

When inspecting cells or doing any kind of work on the plates, do not disturb the active material any more than can be helped. It is delicate and particles are easily dislodged and lost.

Take care that cells are connected together properly when installed or after they have been moved. The positive lug of each cell should connect to the negative, and the negative to the positive, of the cells next adjacent.

It is not well for station attendants who have other duties to perform to attempt to overhaul cells or make other extensive repairs to the batteries themselves.

The additional personal precautions that must be observed when working around a storage battery are those necessary for protecting the eyes, skin and clothing from the corrosive action of the acid. Electrolyte is not strong enough to make a bad burn, but will make the skin sore if it comes in contact with it often enough, on the hands for instance. Contact with the concentrated acid should be avoided.

Immediate application of ammonia or washing soda is the best and quickest method of neutralizing the acid and stopping its action, and either or both must by all means be kept in or near the battery room for instant use.

Ammonia is best kept in a glass bottle provided with a rubber stopper. It may be applied to a splash of acid with the stopper or poured on. Strong ammonia may sometimes give a greater sensation of burning at the time of application to the skin than the acid, so the solution provided should not be too strong, and it is perhaps better adapted to neutralizing acid on clothing.

Washing soda may be applied to spilled or leaking acid in the powdered form, but it is more suitable for use when dissolved in a bucket of water. It should be kept conveniently near so that the hands can be dipped into it frequently while working around the battery. This will prevent much of the annoying smarting and soreness of the skin.

Wear goggles when pouring acid or electrolyte. If a splash of acid happens to enter the eye, wash it out quickly with clean water, warm if possible, then put a

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drop or two of olive oil into the eye. If this is not available, clean engine or turbine oil is good and may be used in the absence of olive oil.

Old clothing, wool preferably, should be worn when any considerable amount of work is to be done on the battery, as some acid is bound to get on the clothes, and wool resists the action of the acid better than cotton. Aprons, oversleeves, leggings, etc., made of burlap, sacking or other thick material offer some protection. Rubber aprons are good, but it is doubtful if their cost is justified, and probably they will not be in condition by the time further work is to be done. Proper cleanliness in the battery room and reasonable care in the handling of the hydrometer when moving it from cell to cell will obviate injury to the clothing during the ordinary routine visits.

Angular Velocity Explained

The word "velocity" used by itself ordinarily means *linear* velocity—the *distance* that is traversed in a unit of time. Among American engineers, the most common units of linear velocity are "feet per second," "feet per minute" and "miles per hour." In each case the name itself indicates the way to figure the velocity, if it is remembered that the word "per" always means "divided by." For example, the velocity in feet per second is obtained by dividing the number of feet traversed by the seconds required.

Where the velocity is changing, this method of figuring gives the average velocity over the measured period. In such a case the instantaneous velocity at any moment is approximated by using an extremely small period of time and the corresponding distance. The smaller the period of time taken, the more nearly does the average velocity during that period approach the instantaneous velocity.

Turning now to the subject of angular velocity, everything said about linear velocity applies if angles

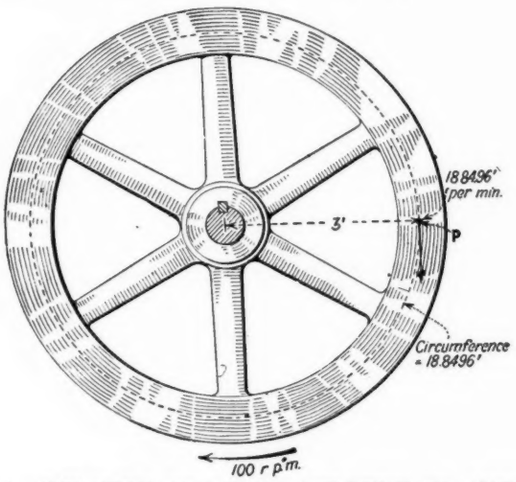


FIG. 1. RELATION OF LINEAR VELOCITY TO ANGULAR VELOCITY

are substituted for distances. When a body is rotating, the radius drawn from the axis of rotation to any point in the body is "sweeping out" an angle, just as the rotating point itself is "sweeping out" distance along the circumference that it travels. The most familiar units of angle are "degrees" and "revolutions," each of the latter being of course equal to 360 degrees. We may then express angular velocity as "revolutions per minute" (r.p.m.), "revolutions per second," "degrees per second," etc.

It is evident that every point in a rotating body has the same angular velocity. The linear velocity of any point in the body, on the other hand, depends on the distance of that point from the axis of rotation. If one

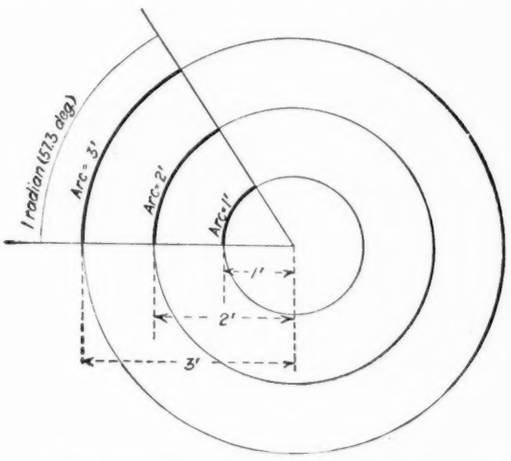


FIG. 2. THE ARC INCLUDED BY ONE RADIAN ALWAYS EQUALS THE RADIUS

point has three times the radius of another, its linear velocity will be three times as much.

If the radius and the angular velocity are known, the linear velocity can always be figured. For example, referring to Fig. 1, suppose that the wheel is rotating at 100 r.p.m., and that it is desired to know the linear velocity, in feet per minute, of the point P, 3 feet from the axis. Point P travels in a circle of 3-ft. radius. Then the circumference of that circle is $3 \times 2 \times 3.1416 = 18.8496$ ft. Since it passes over this circumference 100 times per minute, the total distance covered in a minute by the point P is $18.8496 \times 100 = 1{,}884.96$ ft. Therefore its linear velocity is 1,884.96 ft. per min.

On the other hand, if the linear velocity of point P were given as 1,884.96 ft. per min. the r.p.m. could be easily determined by dividing the distance covered in one minute by that covered in one revolution. In this case it would be $1{,}884.96 \div 18.8496 = 100$ r.p.m.

Another unit of angle much used by mathematicians is called the "radian." As this is often convenient in engineering calculations, its use will be explained. A radian may be defined as an angle of such size that the arc equals the radius. Fig. 2 shows a circle with one radian laid out. No matter what the radius of the circle, the arc included by one radian is exactly equal to it.

This is convenient when changing from angular velocity to linear velocity or the reverse. Suppose the radius of a point is 2 ft., and the angular velocity is 20 radians per second. The linear velocity is then $20 \times 2 = 40$ ft. per sec. This is true because each time the point swings through an angle of one radian it moves 2 ft. (the length of its own radius). Conversely, if the linear velocity is 40 ft. per sec. and the radius 2 ft., the angular velocity must be $40 \div 2 = 20$ radians per second.

To change from radians to degrees or revolutions or the reverse, the following constants may be used: 1 radian = 57.3 degrees, 1 revolution = 6.2832 radians (approximately 6.3). The figure 6.2832 is easily remembered as it is obtained by doubling 3.1416.

Lubrication—Evaporation of Oil

By W. F. OSBORNE*

ONE of the physical properties of oil with which the engineer has to contend in more ways than one, is evaporation. Evaporation of oil causes loss, increased consumption and sometimes deterioration of the oil, and develops a fire hazard that becomes quite serious under certain conditions.

This characteristic of oil, as with all other liquids, is based on the physical property known as *vapor pressure*. The vapor pressure is the result of the tendency of a liquid to change into a vapor of its own accord. A liquid with a high vapor pressure has a tendency to change into vapor much more rapidly than one with a low vapor pressure. For instance, the vapor pressure of water at 60 deg. F. is 0.25 lb., while that of gasoline is 3 lb. From this we can judge that at atmospheric temperatures the rate of evaporation of gasoline is about twelve times that of water. Lubricating oils have a low vapor pressure and evaporate slowly at ordinary temperatures.

The vapor pressure increases with the temperature of the liquid. At 150 deg F. water has a vapor pressure of 3.6 lb. and the gasoline referred to has a vapor pressure of 14.5 lb. When the vapor pressure of a liquid equals the pressure exerted upon its surface, the liquid will boil. In other words, liquids exposed to atmospheric pressure will boil when their vapor pressures rise to 14.7 lb. The sample of gasoline referred to will begin to boil at a little above 150 deg. F. It follows that we can raise the boiling point of a liquid by increasing the pressure and lower it by lowering the pressure exerted upon the surface of the liquid.

Raising the temperature of oil increases its rate of evaporation because it raises its vapor pressure. For this reason the oil in an engine circulating system will vaporate much more rapidly when it is hot than when it is cool. Oil splashed up against the cylinder head will evaporate very rapidly.

Saturation Point

A unit volume of air at any given temperature will hold only a definite amount of oil vapor, depending upon the vapor pressure of the oil. Raising the temperature of the air expands it and permits it to hold more vapor. Consequently, a hot engine room in addition to raising the oil temperature will cause the rate of evaporation to increase.

As long as the saturation point of the air is not reached, the vapor will be invisible just as the moisture in the air is invisible, but when the air becomes fully saturated and then suddenly becomes cooled, part of the vapor will condense, and mist is formed. In the engine room this frequently appears as "smoke" coming from the engine. In most cases it really is simply oil vapor, as can be proved by holding a cold piece of metal in the "smoke" and seeing how oily it gets. Although some of this smoke may on occasion be due to oil that has actually been carbonized by splashing on the cylinder heads, or coming into contact with a very hot heater, by far the greater percentage of engine-room smoke is oil vapor from the oiling system condensed by the cooler air of the engine room.

*Supervisor Manufacturers' Service, Texas Co.

The rate of evaporation is also influenced by the frequency with which the air immediately above the oil surface is changed. One cubic foot of air can hold only so much vapor, and as soon as this point of saturation is reached no more vapor will be given off by the oil. If a fresh cubic foot of air takes its place it, too, must be saturated, and more vapor has to be given off. A continuous flow of air will increase the rate of evaporation very considerably, regardless of the characteristics of the oil.

Rate of Evaporation

The rate of evaporation of any particular oil at any specified temperature and pressure depends upon the vapor pressures of each of the various hydrocarbons of which the oil is composed. As pointed out in the previous article, oil is composed of numerous hydrocarbons having various boiling points. The constituents having the lowest boiling points have the highest vapor pressures, and consequently evaporate the most rapidly from the oil. This means that the oil that is left will have a lower rate of evaporation, which continuously becomes lower as the lighter parts evaporate.

It is a comparatively simple matter to measure the vapor pressure of two oils and thereby gain an idea of their comparative rates of evaporation. Unfortunately, just as soon as they start to evaporate, the total vapor pressure changes and we no longer have the original comparative values. For instance, one oil might contain a small percentage of a hydrocarbon which will evaporate rapidly at low temperatures. The rest of the oil might evaporate only at very much higher temperatures. Another oil might have exactly the same total vapor pressure, but, being composed of compounds with vapor pressures halfway between the two extremes of the other oil, would evaporate completely at temperatures at which some of the first oil would remain. In other words, on account of the blending and association of the constituents of lubricating oils, it is difficult to state definitely what the rate of evaporation under operating conditions will be from any tests that we have at the present time. The question of evaporation is so very important that it is hoped that a standard method of making evaporation tests will be developed in the near future.

Distillation Test

The nearest approach to an evaporation test which we have at the present time is the distillation test, which is based on the boiling points of the constituents in the oil. It is made by boiling away the oil in a flask, condensing the liquid and measuring the temperature at which each 10 per cent of the liquid is evaporated. Because of the high temperatures required to distill lubricating oils under atmospheric pressure, they tend to decompose into lighter-gravity products and free carbon. This tendency to "crack" makes it necessary to conduct distillation tests of lubricating oils under reduced pressure or partial vacuum. As the boiling point is lowered with reduced pressure, distillation will take place at a much lower temperature, and decomposition, or cracking, can be eliminated.

Schmidt Steam Engine More Efficient Than Largest Turbine*

Application of Steam Pressures up to 800 Pounds to Combined Power and Heating Plants

By O. H. HARTMAN

THE reduction of Germany's coal resources has stimulated the efforts of her engineers towards the more efficient use of the fuel resources. In keeping with this trend are the experiments conducted by Dr. Wilhelm Schmidt, pioneer developer of the superheater, upon the use of steam of over 800 lb. pressure in reciprocating engines of special design. The high-pressure boiler was developed in 1911, and a service of more than 14,000 hours indicates that no great obstacles are in the way of a commercial high-pressure boiler plant.

The boiler originally contained a total heating surface, including the superheater, of 775 sq.ft. and a grate surface of 10.76 sq.ft. In continuous operation the boiler delivered about 1,540 lb. of superheated steam at a pressure of 840 lb. and a total temperature of 842 deg. F. when hand-fired with anthracite having a heating value of 13,500 B.t.u. per pound. After several years of successful operation the capacity of the boiler was increased by adding more grate surface, which enabled it to deliver 2,948 lb. of steam per hour.

> Carefully conducted tests have indicated that it is feasible to generate and utilize steam at a pressure of 800 pounds per square inch and over in reciprocating engines with a probable gain of 20 per cent in efficiency as compared to the best present-day turbine practice. A steam consumption of 5.12 pounds per indicated horsepower was obtained with a 150-horsepower engine.

The first engine, Fig. 1, to be operated at the high pressure was a single-acting unaflow poppet-valve tandem-compound provided with exhaust valves. The exhaust from the high-pressure cylinder passed into the receiver and the front end of the low-pressure cylinder, and on the forward stroke exerted pressure on the low-pressure piston, giving a receiver m.e.p. and i.h.p. The engine was rated at from 100 to 120 hp. at 150 r.p.m. with superheated steam at 60 atmospheres pressure and a total temperature of 842 deg. F.

A number of tests made on this engine during 1912 with the initial pressures ranging from 55.7 to 47.5 atmospheres, showed only a slight gain in economy over the best previous practice with normal pressures. This was attributed to the unusually high cylinder ratio, which did not permit sufficient expansion in the high-pressure cylinder. Need for greater superheat was apparent. Accordingly, a new high-pressure cylinder of somewhat larger diameter was substituted and the initial pressure was reduced to 45 atmospheres to insure safety. The steam to the reheater was cut off. The results gave a net gain in economy of 10 per cent.

During this time multi-stage single-acting engines of unaflow design for operation at from 1,000 to 1,500 r.p.m. were under construction. They were intended to exhaust either to low-pressure turbines or against back pressure in heating plants.

Under the high pressure and high speeds imposed, it became necessary to equip these engines with special low-lift, steam-actuated admission valves. Operating at a steam pressure of 45 atmospheres and a total temperature of 772 deg. F., a steam consumption of from 12.5 to 13.8 lb. per horsepower-hour was obtained, when developing not more than 30 horsepower.

The principal results are given in Table I, in which they are compared with those obtained with other engine types operating at the usual steam pressure. This shows a range in the Rankine efficiency of the high-pressure cylinder from 75.6 to 88.5 per cent. The low-pressure cylinder did not show up so well, the Rankine efficiency range being between 43.6 and 49.8 per cent. The combined Rankine efficiency of the engine varied between 64 and 75.2 per cent. It will be noted that the efficiency of the high-pressure cylinder increased with the higher initial pressure, which is due to the greater density of the steam and the smaller clearance volume causing less cylinder condensation. On the other hand, the pressure drop following release was greater than would appear necessary, which indicates that a further gain in economy could be expected by dividing the expansion into two stages.

Variations in the efficiencies of the high-pressure cylinders during the test were largely due to the use or omission of steam jacketing. The excellent efficiencies obtained in the high-pressure cylinders were not duplicated in the low-pressure cylinders. Except in those cases where additional energy was furnished in the form of superheating the entering steam, the low pressures in cylinder efficiencies were usually under 50 per cent. It will also be noted that they fell off with the more complete expansion within the high-pressure cylinder caused by early cutoff when using high initial pressures.

Recognizing that the most promising field for improving the efficiency lay in the development of the low-pressure cylinder and discarding the theory that the reciprocating engine could not be operated successfully with a high vacuum, all efforts were concentrated to this end.

It was quite natural that high superheat for the entering low-pressure steam should suggest itself as a basis. The required superheat, expressed in degrees, was estimated to be between 1½ and 3 times the total temperature drop between throttle valve and the low-pressure exhaust which would occur if the engine were operated with saturated steam. On this assumption it would be necessary to superheat the steam 1,164 deg. F. for a condensing engine operating with an initial steam

*Extracted from *Zeitschrift Des Vereines Deutscher Ingenieure.*

pressure of 60 atmospheres. This high superheat is, of course, impossible in practice.

Nevertheless, it appeared certain that reheating the receiver steam to obtain a reasonable amount of superheat was a step in the right direction. Accordingly, the first experimental engine was thoroughly overhauled and equipped with new cylinders, measuring 11.1 in. and 26.5 in. in diameter, respectively, the stroke being maintained at 23.4 in. The more important results of the tests that followed are given in Table II.

For every one per cent increase in the vacuum the heat consumption decreased 1.2 per cent, a fact that perhaps disproves the common theory that the most efficient vacuum for the steam engine lies somewhere between 26 and 27 inches.

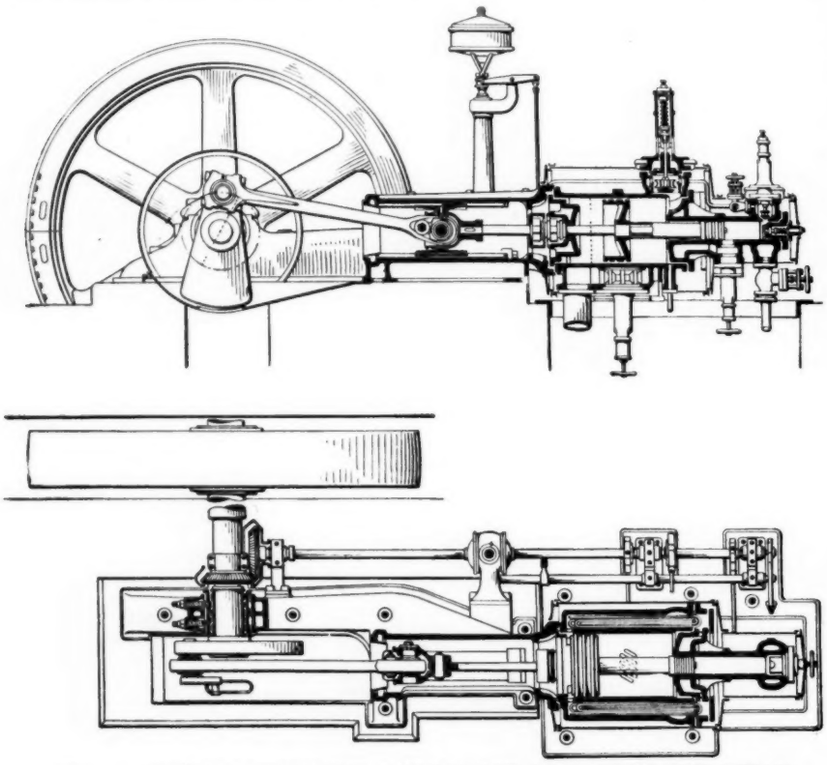


FIG. 1. TANDEM COMPOUND ENGINE FOR HIGH-PRESSURE STEAM

The steam consumption dropped to the unprecedented figure of 7.9 lb. per i.hp.-hr. at 80 per cent of rating with a total initial steam temperature of 608 deg. F. and a vacuum of 28.3 inches.

In order to determine further the advantages of interstage reheating to obtain the most efficient superheat, two tandem-compound engines were interconnected to form a quadruple expansion engine. Provision was made for reheating the steam in the various receivers with live steam taken from the boilers. Table III gives the results obtained.

At a load of 147.4 hp. the steam consumption per indicated horsepower-hour was found to be 5.72 lb., which was the lowest on record. The total heat input based on a feed-water temperature of 32 deg. F. amounted to 8,197 B.t.u., giving an over-all Rankine efficiency of 81.7 per cent. Considering the makeshift coupling of the engine and the manifestly incorrect proportions of the cylinders, there should be little doubt that further increase in economy is possible. It is estimated that the heat input per horsepower could be reduced to 7,920 B.t.u. in a properly designed engine operating under practical conditions.

THE FIELD OF THE HIGH-PRESSURE CONDENSING ENGINE

In spite of the encroachment of the turbine there still is a wide field for the application of the steam engine in capacities up to 1,500 hp. Development along this line would therefore result in large fuel savings.

The advantages offered by high-pressure steam of 800 lb. and over are not confined to the greater heat content per pound and consequent greater working range. As previously intimated, its high temperature makes it an ideal medium for reheating the receiver steam between the cylinders of multi-expansion engines. This procedure would insure dry steam for every cylinder,

TABLE I—COMPARATIVE EFFICIENCIES OF ENGINES

	Types of Engines									
	Superheated Steam Poppet Valve Engine, Schmidt	Tandem Compound, v.d. Kerchove	Locomobile, Wolf	Locomobile, Wolf	High-Pressure Tandem-Compound Engines, Schmidt					
Date of Test	1897	1903	1908	1911	April 13, 1912	April 16, 1912	April 20, 1912	June 18, 1913	June 19, 1913	June 20, 1913
High-pressure cylinder dia., in.	14.1	12.8	7.8	7.8	5.5	5.5	5.5	7.1	7.1	7.1
Low-pressure cylinder dia., in.	29.5	22	14.9	15.7	19.7	19.7	19.7	19.7	19.7	19.7
Stroke, in.	31.5	33.5	15.7	15.7	22.6	22.6	22.6	22.6	22.6	22.6
Revolutions per minute	81.7	126.1	236.6	243.7	150	150	149.5	150.8	151.2	150.7
Mean effective pressure, high-pressure cylinder, lb.	49.6	44.1	52.4	67 1	321.9	335.1	296.9	221.9	223.4	166.1
Mean effective pressure, receiver, lb.	2.2	.....	.....	.....	4.4	4.2	3.5	3.2	4.1	3.8
Mean effective pressure, low-pressure cylinder, lb.	14.1	14.1	14.8	16.1	14.7	14.6	10.7	14.6	13.3	10.4
Indicated horsepower, high-pressure cylinder	64.3	156.2	60.2	75.6	70.8	73.5	65.1	83.1	83.7	63.5
Indicated horsepower, receiver	10.1	.....	.....	.....	11.6	11.2	9.2	8.7	10.9	10.4
Indicated horsepower, low-pressure cylinder	47.8	112.5	50.5	63.9	36.2	34.8	26.6	32.9	31.7	24.4
Total indicated horsepower	122.2	268.7	110.7	139.5	118.6	119.5	100.9	124.7	126.4	98.3
Initial pressure, lb., Abs.	170.5	138.1	221.9	213.1	786.4	808.5	661.5	632.1	632.1	470.4
Pressure low-pressure cylinder, lb., Abs.	6.6	10.2	14.7	15.7	12.0	10.5	1.5	6.1	6.1	0.4
Vacuum, in., Hg.	27.9	27.9	27.3	27.4	28.6	28.6	28.6	28.6	28.6	28.6
Initial steam temp., high-pressure cylinder, deg. F.	661.4	572	724	869	780.8	781	800.6	667.4	789.8	789.2
Final steam temp., high-pressure cylinder, deg. F.	.....	.....	345	503	257	.....	.....	.....	.....	.....
Initial steam temp., low-pressure cylinder, deg. F.	.....	.....	451.4	503	316	.....	.....	.....	.....	.....
Hourly total steam consumption, lb.	1,144	2,749	908	1,012	880	884.4	706	961	849	664
Steam per total indicated horsepower, per hr., lb.	9.35	10.2	8.2	7.2	7.4	7.4	6.9	7.7	6.7	6.7
Total heat consumption per indicated horsepower, hr., B.t.u.	12,672	13,424	11,373	10,573	10,612	10,355	9,900	10,375	9,464	9,543
Rankine efficiency high-pressure cylinder, per cent	78.5	86.0	86.0	80.0	75.6	75.6	80.0	82.0	87.0	88.5
Rankine efficiency low-pressure cylinder, per cent	52.4	50.0	60.0	66.6	43.6	41.1	47.3	43.4	46.5	49.8
Rankine efficiency of engine	68.2	67.5	69.2	77.0	64	65	69.5	68	73	75.2

with a resulting large increase in economy. In fact, the gain is so great that in some instances it would pay a plant to install a small boiler delivering steam at high pressure for superheating the receiver steam of existing engines. It may likewise be applied to superheating the steam intended for low-pressure turbines that are operating in conjunction with reciprocating engines.

Non-condensing Engines Operating Against High Back Pressure

Some of the early failures with high initial steam pressure have resulted in unwarranted hesitation on the part of engine builders to encourage their construction.

TABLE II—TANDEM-COMPOUND ENGINE, OPERATING WITH SUPERHEATED STEAM AND INTERSTAGE SUPERHEATING, WITH LARGE RATIO OF EXPANSION IN L. P. CYLINDER

Date of Test	Mar. 9, 1921	Feb. 25, 1921	Mar. 2, 1921	Apr. 2 1921
Revolutions per minute	146.0	145.6	145.2	145.6
Mean effective pressure, high-pressure cyl., lb.	17.1	19.2	19.1	19.1
Mean effective pressure, low-pressure cyl. lb.	5.45	5.14	5.38	5.26
Indicated horsepower, high-pressure cylinder	50.2	53.3	51.6	52.3
Indicated horsepower, low-pressure cylinder	52.0	49.0	51.0	50.1
Total indicated horsepower	102.2	102.3	102.6	102.4
Initial steam pressure, lb. abs.	110.2	110.2	117.6	122.0
Pressure entering low-pressure cyl., lb. abs.	13.9	16.1	18.3	19.8
Vacuum inches of mercury	28.3	26.5	26.0	25.6
Initial steam temperature, deg. F.	608	600	617	581
Final steam temp., high-pressure cylinder, deg. F.	266	268	293	268
Initial steam temp., low-pressure cyl., deg. F.	413	413	428	425
Hourly total steam consumption, lb.	815.1	884.4	895.4	916.3
Steam consumption per indicated horsepower, per hr.	7.98	8.64	8.73	8.93
Total heat consumption per indicated horsepower, B.t.u.	11,175	12,078	12,236	12,414
Rankine efficiency high-pressure cylinder, percent	78	81.2	78.5	82.3
Rankine efficiency low-pressure cylinder, percent.	80	81.2	85.0	81.8
Rankine efficiency of engine, percent	80	83	84	84.2

A little consideration of the theoretical possibilities, as shown by a Mollier diagram would indicate a decided advantage to be derived from the large amount of heat convertible into work. The diagram will show that even with back pressures as high as 73.5 lb. and an initial pressure of 1,161 lb., a large percentage of the total heat is available for power.

TABLE III—FOUR-STAGE HIGH-PRESSURE ENGINE WITH INTERSTAGE SUPERHEATING.

Date of Test	May 19, 1921
Mean effective pressure, high-pressure cylinder, lb.	301.3
Mean effective pressure, first intermediate cylinder, lb.	58.9
Mean effective pressure, second intermediate cylinder, lb.	8.2
Mean effective pressure, low-pressure cylinder, lb.	4.9
Indicated horsepower, high-pressure cylinder	35.2
Indicated horsepower, first intermediate cylinder	27.7
Indicated horsepower, second intermediate cylinder	36.75
Indicated horsepower, low-pressure cylinder	47.75
Total indicated horsepower	147.4
Initial steam pressure to high-pressure cylinder, lb., abs.	793.8
Steam pressure to first intermediate cylinder, lb., abs.	246.9
Steam pressure to second intermediate cylinder, lb., abs.	57.3
Steam pressure to low-pressure cylinder, lb. abs.	11.3
Vacuum, inches Mercury	28.6
Initial steam temperature, high-pressure cylinder, deg. F.	815
Final steam temperature, high-pressure cylinder, deg. F.	572
Initial steam temperature first intermediate cylinder, deg. F.	568
Final steam temperature first intermediate cylinder, deg. F.	365
Initial steam temperature second intermediate cylinder, deg. F.	536
Final steam temperature, second intermediate cylinder, deg. F.	212
Initial steam temperature, low-pressure cylinder, deg. F.	436
Total steam consumption per hour, lb.	7,563.6
Steam consumption per indicated horsepower, hr.	5.12
Total heat consumption per indicated horsepower hr.	8,197
Rankine efficiency of engine, per cent	81.7
Rankine efficiency, high-pressure cylinder, per cent	91
Rankine efficiency, first intermediate cylinder, per cent	79.8
Rankine efficiency, second intermediate cylinder, per cent	78.6
Rankine efficiency, low-pressure cylinder, per cent	80.0

Fig. 2 clearly shows that the ratio of the work done by the engine to the work still available from the exhaust team is much greater when the initial pressure is 852 lb. gage than with the present maximum of 205 lb. gage.

TABLE IV—HEAT CONSUMPTION IN B.T.U. OF RECIPROCATING ENGINES

Initial Steam Pressure	Back Pressure 14.7 lb.	73.5 lb.	161.7 lb.
214 lb.	20,592 B.t.u.	39,600 B.t.u.	.....
426 lb.	15,285 B.t.u.	22,700 B.t.u.	34,056 B.t.u.
855 lb.	11,840 B.t.u.	15,364 B.t.u.	19,760 B.t.u.

The gain in the ratio of $(f_1 + f_2)$ to f_3 is very decided, even for comparatively small increments in the initial steam pressure.

Comparative Economy of High-Pressure Engines and Bleeder Turbines Operating Against Back Pressure

In both cases that part of the exhaust steam which cannot be utilized for heating purposes, may be passed through a pressure condenser. The resulting condensate, being under pressure, will be at a corresponding high temperature and may be efficiently used for feeding the boilers.

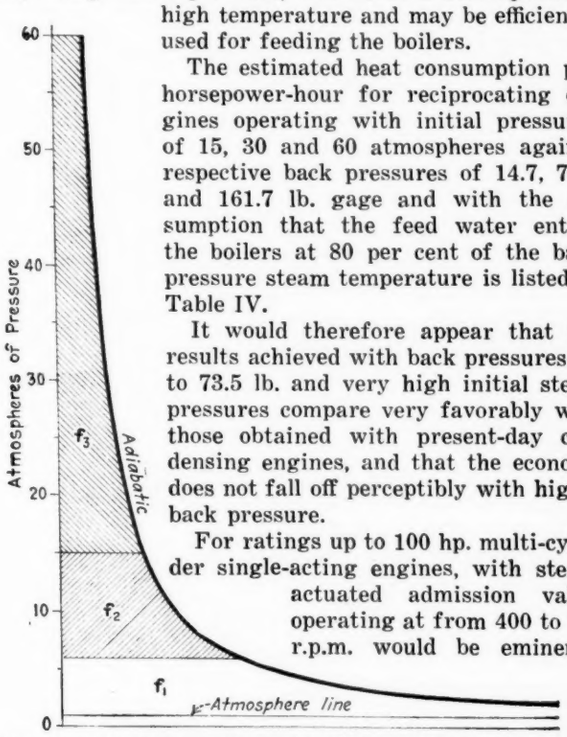


FIG. 2. COMPARATIVE INDICATOR DIAGRAMS OF HIGH- AND LOW-PRESSURE ENGINES

The estimated heat consumption per horsepower-hour for reciprocating engines operating with initial pressures of 15, 30 and 60 atmospheres against respective back pressures of 14.7, 73.5 and 161.7 lb. gage and with the assumption that the feed water enters the boilers at 80 per cent of the back pressure steam temperature is listed in Table IV.

It would therefore appear that the results achieved with back pressures up to 73.5 lb. and very high initial steam pressures compare very favorably with those obtained with present-day condensing engines, and that the economy does not fall off perceptibly with higher back pressure.

For ratings up to 100 hp. multi-cylinder single-acting engines, with steam-actuated admission valves operating at from 400 to 750 r.p.m. would be eminently suited. Their construction would be compact and comparatively low in cost.

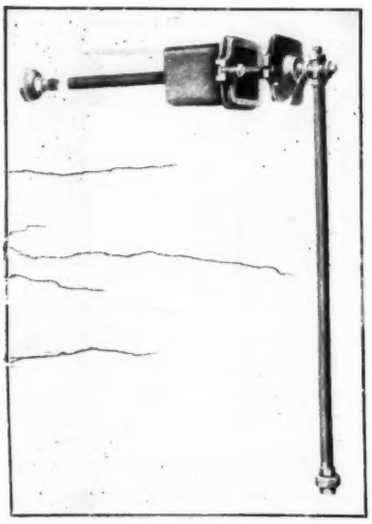
For ratings up to 1,500 hp. single-acting tandem-compound engines with the steam acting upon opposite sides of the high- and low-pressure stuffing boxes makes it possible to obtain steam for heating at any one or more of three pressures; namely, from the receiver, from the low-pressure cylinder exhaust, and when desired part of the latter could be diverted to and compressed within the space behind the low-pressure piston. A suitably heavy flywheel would in the latter case be required to maintain smooth operation, due to the greater resistance offered on the return stroke.

Large units up to 5,000 hp. should follow along the lines of the present tandem-compound condensing engine. No insurmountable difficulty need be feared from the use of a high-pressure stuffing box which may be designed with labyrinth packing rings to throttle the steam leakage. This can be piped to the receiver, while further leakage could be taken up by a stuffing box of the usual design.

The Sesqui-Centennial Exhibition that is planned for 1926 in Philadelphia was indorsed by the Pennsylvania Congressional delegation recently in caucus at Washington. Some trouble is expected in getting Congress to make the needed appropriations, at least until a large sum is raised in Philadelphia.

New Flue-Gas Filtering System for CO_2 Apparatus

Every boiler operator familiar with CO_2 equipment knows that the first requisite for successful operation is cleanliness and that time is required for blowing out the gas sampling lines and keeping the mechanism clean. Realizing this situation, the Uehling Instrument Co., 71 Broadway, New York City, after experimenting in perfecting means for excluding soot and dirt from the gas sampling lines, has adopted a material that combines the necessary porosity and refractory qualities in the new Uehling "Pyroporus" filter, which is placed on the inlet end of the gas sampling line inserted in the flue or last pass of the boiler furnace. This filter consists of a heavy but highly porous disc, held in a cup-shaped casting by means of a bolt. It is not injured by high temperatures. Formerly, the gas was withdrawn through an open-ended pipe and the filtering was accomplished with cotton waste; this necessitated more or less blowing out of the gas line and required frequent renewal of the filtering material. With the new arrangement the soot builds up on the "Pyroporus" filter and does not appear to enter the pores to any extent, after the filter has been in service for months without having been blown out or replaced and without apparently offering appreciable increased resistance to the gas flow.



"PYROPORUS" FILTER FOR FLUE GASES

It is not yet known what life may be expected of these filters, but present indications are that they will last for several years without any attention. To facilitate inspection and replacement, the manufacturer has developed a frame to be inserted in the brickwork and a holder for the sampling pipe. In the illustration the holder is shown detached from the frame. It is quickly fastened in place by two bolts. By loosening the nuts on these bolts and by unscrewing the union shown at the bottom of the section of the sampling line, it requires but a moment to withdraw the filter through the frame, which is the width of two bricks; hence it is a simple matter to insert it in the setting without cutting a large hole in the brickwork. When the sampling line is to be inserted through a metal casing, as with a horizontal return-tubular boiler, the frame is omitted and the holder is bolted directly to the metal casing of the boiler.

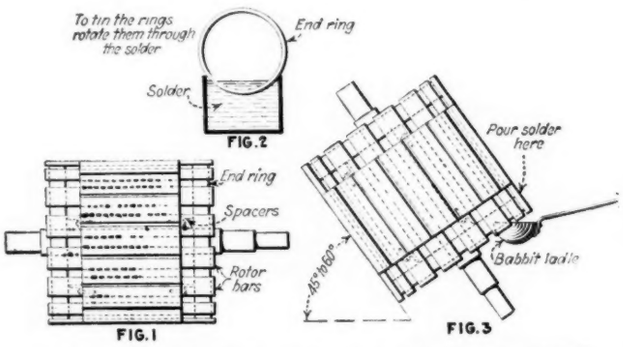
This filter may be used for all makes of instruments, and the frames and holders are useful in connection with pyrometers, draft gages and for providing convenient openings in the furnace for test and observation purposes. The method of installing is shown in the illustration.

Soldering the End Rings on Squirrel-Cage Rotors

By Marin Phillips

End rings are fastened to the rotor bars of induction motors in various ways. In some small motors flat rings are used in which holes are punched to receive the ends of the bars and one is soldered to the other. In other cases the bars are bolted or riveted to the end rings and then soldered. Where bolts are used, lock washers are usually placed under the nuts. Sometimes trouble will occur in the rotor due to the bars becoming unsoldered, caused by the motor being stalled or by frequent hard starting. Some end rings are made from a straight copper bar bent to form a ring and the ends butted together. Such rings may develop a bad joint and heat up the rotor. Some of the lock washers may break or lose their temper by being heated up, and allow the machine screws that hold the bars and rings together to loosen. The spacers (Fig. 1) that keep the end rings equal distances from the rotor core may be worn or broken, and allow the rotor bars and end rings to have end play in the slots, which will also loosen the bars from the rings. When the rotor bars become unsoldered, the solder will be spread around on the stator winding, which is easy to detect by inspection.

Rotor trouble usually makes itself known by the motor running at a lower speed than it should with a full load. Take, for example, a six-pole motor operating on a 60-cycle circuit. The rotating magnetic field is revolving at 1,200 r.p.m., but the rotor lags behind and runs at about 1,150 r.p.m. when carrying full load as shown on the name-plate of the motor. If there is any doubt as to the speed of the motor, it should be tested to see if it has an overload. Suppose it was tested and found to be carrying about full load and that the speed was



FIGS. 1 TO 3. METHOD OF SOLDERING END RINGS ON INDUCTION-MOTOR ROTORS

1,100 r.p.m. or less, assuming that the frequency was up to 60 and that the bearings were in good condition. Such conditions are a good indication that the rotor needs overhauling and resoldering. All rivets and screws should be examined for loose or broken ones. If the motor cannot be spared from service long enough to take end rings and bars off to be cleaned and retinned, it may be cleaned and soldered and put back into service without disassembling. However, this method usually serves only as a temporary repair, as there may be dirt and oil between the bars and end rings, which will prevent a good job of soldering being done. If time can be taken to remove the bars and end rings and retin them, it will pay in the long run, as the rotor will then be in as good a condition as a new one.

The end rings are tinned by rotating them through a pot of hot solder (Fig. 2), and wiping all excess solder off with a clean rag. The ends of the bars are tinned by dipping the ends in the pot of solder and wiping. The rings and bars are cleaned well by rubbing with fine emery cloth and applying a little soldering paste before dipping them in the solder.

A good grade of half-and-half solder should be used, as it takes a higher temperature to melt it than the ordinary solder. The soldering should be done by pouring it on the end ring, as in Fig. 3. A much better and quicker job can be done than by trying to solder by holding a flame on the rotor. The bars and end rings are soldered by tipping the rotor up to an angle of 45 to 60 deg., as in the figure, depending on the size. The solder pot or ladle is held under the end rings and solder dipped out with a small ladle and poured on the ring until it runs off freely, indicating that the ring is hot enough. The rotor is then turned a little to bring a new section over the solder pot, repeating the operation until all the way around. As the rotor is turned, all drops and bars of solder are wiped off so as to keep the rotor as nearly balanced as possible.

In replacing end rings and bars, the new ones should be as nearly like the old ones as possible, for any change in them affects the operating characteristics of the motor. When assembling the bars, new fishpaper cells should be placed in the slots, as they help to make the rotor more rigid by having the bars fit tightly in the slots. In assembling the rotor bars with end rings that have a joint in them, care should be taken not to place the rings with the joints in line. The joint should be on the top of rotor at one end and on the bottom at the other end. When the rotor has been overhauled, it should be checked to see if it is balanced.

Notes on Boiler Pressure Regulation

BY H. G. BURRILL

In the installation of pressure regulators to govern the pressure to be carried by boilers or other pressure vessels, thought should be given as to the proper location of the pressure connection.

If it is desired to control the boiler pressure, where the safety valves on the boiler drums are the upper limit of pressure, as is usually the case, the diaphragm or pressure connection of the regulator should be connected to the drums and not to the main steam header. The reason for this is readily apparent.

Most modern boilers have between their drums and steam header, a superheater, a non-return valve and a stop valve. If a gage was placed on the header, another on the boiler drum and the boiler output was practically zero, the two gages should register the same pressure, as there would be no drop through the superheater or the fittings, due to no flow. If the boiler output was increased, there would be a drop in pressure across the superheater, fittings, etc., between the boiler drum and the steam header. Suppose this drop at 200 per cent boiler rating to be 5 lb. and suppose the regulator to be set for a variation of 5 lb. between "full off" and "full on" position; the safety valves are set for, say 203 lb. and the normal pressure to be carried is 200 lb.; the regulator is then set to close off at 200 lb. and open up at 200 — 5 or 195 lb.

If the regulator was connected to the steam header and the output or flow of steam was small, as soon as the pressure on the headline reached 200 lb. the regulator would close and the pressure on the boiler would be approximately 200 lb. If, however, the boiler was steaming at 200 per cent rating and the drop between the drums and the header was 5 lb., then the regulator would stay on until the pressure in the header was 200 lb., but the pressure in the boiler would be 200 + 5 lb. (drop) or 205 lb., and as the safety valves are set for 203 lb. the boilers would "pop." If the regulator was connected to the boiler drums, even though the drop between header and drum were large, the regulator would close off at 200 pounds.

Where each boiler has a blower, each blower should have its own regulator, and this regulator should have its pressure connection taken from the boiler drum and not from the header. Where the installation is such that one blower serves a battery of boilers, the pressure connection should be from the drum of each boiler of the battery to be served. This should be by means of a small header, connected to one drum of each boiler. These connections should be provided with a check valve and shut-off valve next to each boiler.

Where boilers in a battery are provided with one blower and the superheater of each boiler is equipped with a safety valve set lower than the drum valves, a central point on the header to which these boilers are connected may suffice, as the probable drop from the superheater to the steam header would not be over two or three pounds.

For other regulators, such as boiler-feed pump excess-feed regulators, the steam connection should be connected as near the boiler as possible and in no case next to the pump, as the drop through the branch line to the pump may be as high as 10 pounds.

Proper provision must be made for difference in elevation between the pressure connection on the boiler or steam header and the regulator diaphragm, as the additional pressure (when the regulator is below), due to the water column or water leg must be taken into consideration, and even this is likely to vary owing to air getting in the line.

When connecting air-compressor unloaders, the connection to the small high-pressure piston that operates the unloader valve should be connected to the storage tank that the air compressor supplies and not to the line leading from the compressor.

The peripheral speed of a commutator or slip ring is the speed at which its surface is moving under the brush contact. It may be calculated by multiplying the diameter of the commutator or ring in feet by 3.1416 and by the number of revolutions per minute. Brush manufacturers rate their brushes for the maximum peripheral speed to which they are adapted. This rating applies to direct-current types of machines of average design and may be increased from 20 to 50 per cent for slip-ring service. Permissible peripheral speed is detemined largely by the coefficient of friction of the brush, but there are other factors having an influence, and for this reason it is advisable to base the selection of a brush on the manufacturer's rating for permissible peripheral speed rather than on the coefficient of friction.

Never place a new boiler in service without first thoroughly drying out the setting; otherwise cracks will develop.

Power in Industrial Plants—A New Presentation of Some Old Facts

By JOHN S. GRIGGS, Jr.

IN the past I have tried to emphasize the fact that the power plant in an industrial establishment must be considered as a manufacturing plant by itself. Its output of power, heat, light, etc., should be measured and accounted for just as carefully as the total output of any separate department or of the factory itself.

In the large central stations this is exactly what occurs. They *are* power factories, since their only output is electrical energy. They cannot even sell the exhaust heat, which is more than 80 per cent of their total product. With such a large percentage of unavoidable waste it is necessary to practice every economy in the generation and distribution of the useful product. The same principles of economical production can be applied in private power plants, but the extent to which they can be carried will depend on the size of the plant, design and local conditions.

Any discussion of this subject leads sooner or later to the fact that there are two general methods of securing economy. One is more intelligent operation of existing equipment and factory distributing systems, and the other is the installation of new and modern apparatus.

Lower operating costs in the present plant present a very attractive field for the engineer. In order to make any progress, it is necessary to know how the plant is now being run. Plant records, if available, must be examined, checked and analyzed. If there are no records, instruments must be put in to give the essential information. These will give weight of coal burned and water evaporated each day, quality of combustion (CO_2 in flue gases), draft and temperature of feed water and flue gases. The coal must also be analyzed and its heat value determined.

If live steam is used for process work, it should be metered, just as electricity is metered. When live steam is used for heating buildings or other low-temperature work, such as drying, water-heating, etc., investigation should be made as to the possibility of using exhaust steam or other waste heat for such purposes. This is the most frequent and often the greatest item of waste and will be considered more fully later.

Steam leaks should be stopped. Small leaks at high pressures are extremely wasteful. Distributing systems for electricity, compressed air, hydraulic power or refrigeration should all be carefully examined. It has been said that the consulting engineer is a mechanical doctor. In such cases as this he is. These instruments and records are the things that he needs to diagnose the case of the sick power plant, and without this information he can do little or nothing.

With the information thus obtained, the engineer can make definite recommendations. Coal and water records show at once the evaporation of water per pound of coal. When this is low, it is almost certain that the CO_2 in the gases will also be low. This is a condition that can be easily corrected, even in hand-fired plants.

Good combustion can be secured if the firemen are instructed in the proper methods of firing and have combustion indicators (CO_2 instruments) to show them what they are doing. An increase in the average CO_2 from 5 per cent to 13 per cent might easily result in a 30 per cent reduction in the coal bill, together with probable reduction in labor, ash removal and other incidental expenses. At the same time there would be an increase in the plant's capacity. A thorough investigation of the power-plant operating conditions will uncover other things that can be improved.

The exhaust steam from non-condensing engines contains from 88 to 94 per cent of the heat in the steam at the throttle. Condensing engines allow from 80 to 85 per cent of the heat to escape in the cooling water. In spite of this it often pays to change the condensing unit to one running non-condensing. This is ordinarily the case when live steam is used for any part of the heating or process work, and where exhaust-steam could be used just as well for the purpose. It is necessary, of course, that practically all the exhaust be utilized if this change is to be made with the greatest advantage.

There are certain facts about power, boilers, steam, etc., that have been known for years, but a wide gap exists between knowledge and practice. In spite of scientific developments, the average industrial power plant is still a mere collection of equipment selected without any controlling plan, and operated on a hand-to-mouth basis. This situation is proof that the facts have not yet gone home. Power, therefore, considers it worth while to print this abstract of a paper recently presented by Mr. Griggs at a combined meeting of the A.I.E.E. and the A.S.M.E. in New York City.

This field has been sadly neglected. Exhaust steam at or near the pressure of the atmosphere can be used for a great variety of purposes, particularly for all sorts of drying, both direct and indirect, when the object is only to remove moisture. Water can be heated for all domestic purposes, for use in tanneries, bleacheries, all textile plants, dyehouses and scores of other plants. Water may be heated slowly and stored during the night to be available for the rush start in the morning.

It is a great mistake to heat buildings with live steam when there is any exhaust steam available. It is frequently possible to use all the waste steam in winter for these purposes, and run condensing in the summer. The engine or turbine exhausting to processes is little more than a reducing valve between the boilers and the factory, taking out from 6 to 12 per cent of the heat put into the steam by the boiler. Since process requirements are likely to be variable, it is not always possible to utilize all the exhaust, and some may be wasted.

When there are several units in the plant, it may be possible to run some condensing and others non-condensing, and thus get enough flexibility to suit the changing conditions. The best-known method is to use

an "extraction" or "bleeder" turbine. In this machine practically all the steam passing the throttle can be extracted at an intermediate point. In fact any amount, ranging from zero to the total steam supplied, may be extracted. The remainder passes through the low-pressure section of the turbine to the condenser.

The bleeder turbine combines the greatest flexibility with the greatest economy and must come into general use in plants where steam is used at lower than boiler pressure for any purpose. When no steam for factory uses is needed, the turbine automatically operates as a straight condensing unit with the economy of such a unit.

Steam May Be Bled at High Pressure

The pressure at which steam can be extracted is limited only by the pressure at the throttle. I have a case where superheated steam, delivered to the throttle at 225 lb., is extracted at a pressure of from 80 to 100 lb. for manufacturing purposes.

There are other cases where exhaust steam is produced in large quantities and where there are no process requirements. Forge shops are an example. Here the exhaust from hammers and presses can be used to great advantage in either a low-pressure or mixed-pressure turbine. The latter is preferable since power requirements do not vary with quantity of steam available from the forge shop. Waste heat from furnaces in steel mills and from cement kilns has been used very successfully, but only to a limited extent. Waste heat boilers will undoubtedly be used much more in the near future.

Most of the improvements mentioned can be applied to existing plants with great benefit. But no improvements in operating methods or conditions can give the results that are secured from properly designed new plants.

The developments in the general power and industrial fields now make it possible for the engineer to design a compact, simple and very economical power house. It is essential that the preliminary study be made in great detail. In this investigation the whole manufacturing plant must be included, the processes examined, and the needs of departments understood, particularly as to their requirements of heat and power. The question of heat, already discussed at some length, will often be the controlling factor in deciding the size and type of plant. It comes especially to the front in deciding whether to purchase electric power and build a steam plant for heating and process requirements alone.

Central Stations Cannot Use Exhaust Heat

The efficiency of the boilers and electrical generators will be practically the same in either the central station or industrial plant. The prime mover is the key to the situation. It is evident that machines that waste from 80 to 85 per cent of the heat in a plant many miles away can hardly compete with one in a factory where all or any considerable part of this waste heat can be turned into useful work, and where, if not so used, it will be necessary to operate a steam plant of 80 to 85 per cent of the size of the total power requirements, in addition to paying the bill for electrical energy.

The actual design of the plant for a given location must consider the method of handling and dumping coal, ash removal and chimney sites. These must be planned to give freedom for extension; they have sometimes blocked additions or made them difficult and expensive.

Coal for regular operation should be handled direct from the cars or other sources of supply to the crusher, and delivered to an overhead bunker in the boiler room, thence flowing by gravity through automatic coal scales and chutes to the stoker hopper. Steam-flow meters should be supplied for each boiler, so that the coal scales and flow meters can furnish a daily parallel record of the individual performance of each boiler. CO_2 indicators on each boiler should be used to check the results. Then any falling off in efficiency or capacity can be noted and corrected at once.

The type and size of boilers will be determined by local requirements. In any case there should be at least one reserve unit. The ratings at which the boilers can best be operated depends on the demand on the plant. For industrial plants a rating of 175 to 200 per cent for regular operation, with ability to carry 250 per cent peaks when necessary, gives very satisfactory results. Such design will take care of the possibility of poor coal. The type of stoker will depend on the character of the coal available.

Such equipment as boiler-feed pumps, condensers and other auxiliaries should be designed to give a perfect heat balance in the power house, so that the feed water will always be as hot as possible. If the feed water can be heated by waste heat from other sources, some or all of the auxiliaries may be electrically driven from the main source of electric supply.

The Well-Operated Plant

After the plant is built, the operation and the resultant economies are almost entirely regulated by the methods followed in the care of the steam end of the plant. Only minor savings can be effected in the engine room, but the losses that can occur in the boiler end of the station are of great importance.

All apparatus must be kept in good physical condition, and instruments should be properly calibrated at frequent intervals. Above all, the records should be checked up and *used*. They are useless if filed away. Constant comparison, study of changes and correction of defects which may show, are essential. The plant *must* be in charge of a competent engineer. Such a power house will be a joy to the owner, the chief engineer and to the annual balance sheet.

Coefficient of friction is the ratio between the tangential pull at the brush face and the pressure normal to this contact. It ranges from 0.05 to 0.30 under normal operating conditions and varies with the grade of brush, the pressure per square inch, condition of commutator or ring surface, and even to a measurable extent with atmospheric conditions. The number of factors influencing this characteristic make it very difficult to establish a standard test. For this reason some manufacturers are now defining the cofficient of friction of their various grades of carbon brushes in general terms such as high, medium and low rather than in specific figures. The only occasion for knowledge of specific figures of coefficient of friction is the necessity for calculating heat losses due to friction. In such cases the exact coefficient of friction must be known in order to carry out the calculation.

The Geological Survey reports that in 1921 the production of bituminous coal was 73 per cent of that in 1920, the exports were 60 per cent and domestic consumption 76 per cent.

The Steam-Engine Indicator*

Checking the Reducing Rig for Errors

EVEN though a reducing rig or motion be theoretically correct, poor construction or wear of the joints may result in an indicator diagram with a serious error. Usually, such imperfections tend to cause the events toward the ends of the diagram to be crowded together and to shorten the diagram. Many diagrams are worthless on account of errors in the motion.

It is very vital that the indicator drum travel bear a constant ratio to the crosshead travel. Consequently, the accuracy of the reducing rig should be checked when first applied and at such times as the engineer may feel

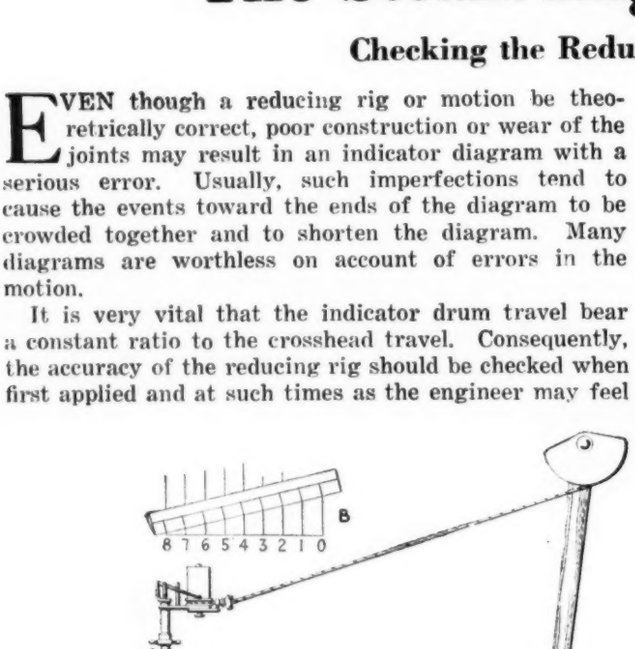


FIG. 1. METHOD OF CHECKING REDUCING MOTION

is necessary, bearing in mind that the more the rig is used the more likelihood there is of joint wear.

In Fig. 1 is outlined a common and fairly accurate method of testing the rig. The crosshead is moved to the end of the stroke, and a mark *O* is scratched on the guide in line with a similar scratch on the crosshead. Other lines are laid out on the guide at constant intervals, as for example, by dividing the engine stroke into 8 equal divisions as shown.

The crosshead is brought to the initial point *O*, the indicator is connected up and a card slipped on the drum. The pencil motion is raised by the finger and a vertical line marked on the drum card. The crosshead is now moved to position 1 and a second pencil mark drawn on the card. This procedure is followed at each division of the crosshead travel. The indicator diagram is now removed and the distances between the several vertical lines measured with a rule. If the reducing rig is accurate, the pencil lines will be uniformly spaced; if the rig is inaccurate, it usually will be found that toward the center the lines are crowded.

For the purpose of measuring these lines and for other measurements required in the study of the indicator diagram, an engineer's rule, Fig. 2, is advisable. This has six scales marked off to 20, 40, 60, etc., to the inch. With such a rule any spring in use may be measured by one of the scales.

*This is the sixth of the series on the steam engine indicator.

An interesting demonstration of reducing motions may be secured by the use of the apparatus designed by A. C. Lippincott, which is shown in Fig. 3. This consists of a wooden frame about four feet in length. At the upper right-hand corner is a fulcrum pin that may be adjusted in any direction. At the lower right-hand corner is placed a crosshead and guides, one of which is fitted with a scale. At the left-hand side is placed a

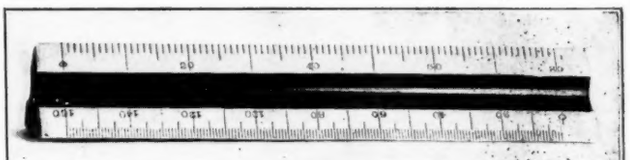


FIG. 2. SCALE USEFUL IN INDICATOR WORK

slide bearing a scale and connected to the reducing motion and a second scale attached to a slide connected by a stiff link to the crosshead. The reducing motion to be tested is placed on the demonstrator. If the rig is accurate, at each division on the crosshead guide scale the marks on the two scales at the left must coincide. Any departure from this shows that an error exists and the distance between the guide and indicator slide-scale reading indicates the extent of the error. The indicator diagram in the upper left-hand corner shows the error detected, the dotted lines giving the true diagram.

Of course an apparatus for demonstrating purposes can be in the hands of but few engineers, since the cost is high compared to the number of times used. On the other hand, every engineer making use of a reducing motion should realize the probability of error incorporated in its construction as well as the errors due to wear. A great many rigs are in use today with the

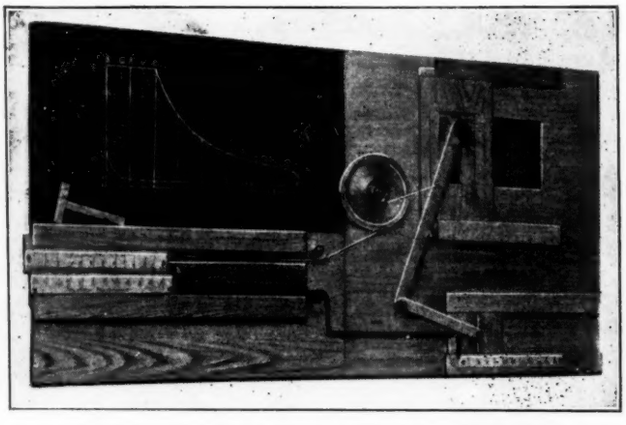


FIG. 3. LIPPINCOTT CHECKING APPARATUS

engineer unaware that their design absolutely precludes the securing of representative diagrams. The extent of the errors impresses one with the importance of using an accurate rig. For this reason the reducing wheel furnished by the indicator manufacturer is to be preferred.

Power from Sewage Gas

In Australia there are a number of city sewage systems in which the gas from the sewage is employed in gas engines for the purpose of driving the pumps that handle the sewage to the treatment tanks and also for the production of electric power. In Parramatta, a city of 13,000 people, the sewage was handled by a steam pumping plant up to 1914. This plant was in operation for sixteen hours out of twenty-four and cost about $4,000 a year for fuel alone. In 1914 a 17-hp. gas engine was installed at the pumping station to replace the steam plant. From that time till the present no other fuel than the gas obtained from the sewage has been employed and the total saving is said to exceed $5,000.

This system has been used in certain institutions in England, and while the results have not been as promising as those secured from Australia's sewage system, the power saved is of enough value to justify the expense of the gas-engine installation. At the Cole-Hall plant, Birmingham, England, it was found that the B.t.u. per cubic foot of gas was 675. The total amount of dry solid matter passed through the tanks in a period of 58 days was four tons which, on a 3 per cent basis, would be equivalent to 133 tons of sewage. The amount of gas secured from this sewage was 25,000 cu.ft. It has been estimated that it would take approximately 2 tons of wet sludge to generate sufficient gas to supply a 25-hp. gas engine for a period of six hours a day, or 150 horsepower-hours.

It has been suggested by various sewage engineers that this gas recovery is of considerable interest, since the power secured from the sewage in the average town would furnish enough electricity to supply the street lighting system. Since the sewage, after the heat treatment necessary to produce gasification, is free from the odor that is so objectionable in various sludge works, it would appear that from the viewpoint of the removal of a public nuisance, as well as the securing of power for practically nothing, this plant should be worthy of investigation by American engineers.

A German Peat-Digging Machine

By H. Wieland Los

Some years ago the digging of peat fuel by machinery was introduced by Dr. W. Wieland, of Oldenburg, Germany. One of these machines was placed in service in Holland during 1920 and worked quite satisfactorily.

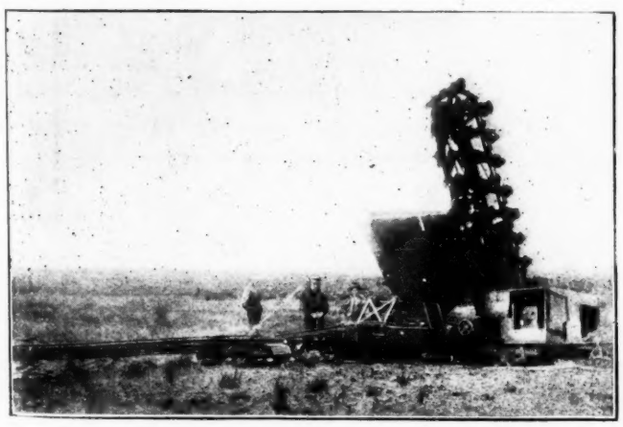


FIG. 1. PEAT-DIGGING MACHINE

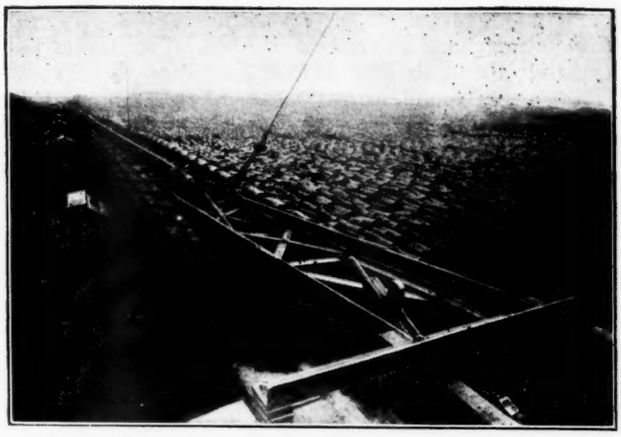


FIG. 2. PEAT BRIQUETS AND CONVEYOR

A newer type has been developed and is shown in Figs. 1 and 2. The peat material is elevated, mixed, cut into briquets and then spread on the worked-over ground in the rear of the machine. The machine is driven by a 40-hp. electric motor, the current being supplied through an overhead wiring system connected to a flexible cable.

The raw material, after briquetting, is discharged on sheet-iron plates attached to an endless chain. The conveyor, Fig. 2, is mounted on an iron frame resting on caterpillar rollers and extends across the field. The briquets are deposited on the conveyor, which moves at a velocity of 42 ft. per min. When the entire conveyor top is covered with the briquets, the plates are tilted, dumping the briquets on the worked-over land. The machine and conveyor then move forward and make room for another row of briquets. In Fig. 2 the appearance of the field covered with briquets is plainly revealed.

The machine has a capacity of 7,000 briquets, of a total weight of 4 tons per hour. After being air-dried for a couple of weeks, the briquets are piled up much like cordwood and are ready for the market. The fuel is of first-class quality, since the vegetable matter is thoroughly mixed, making the peat especially suitable for gas producers.

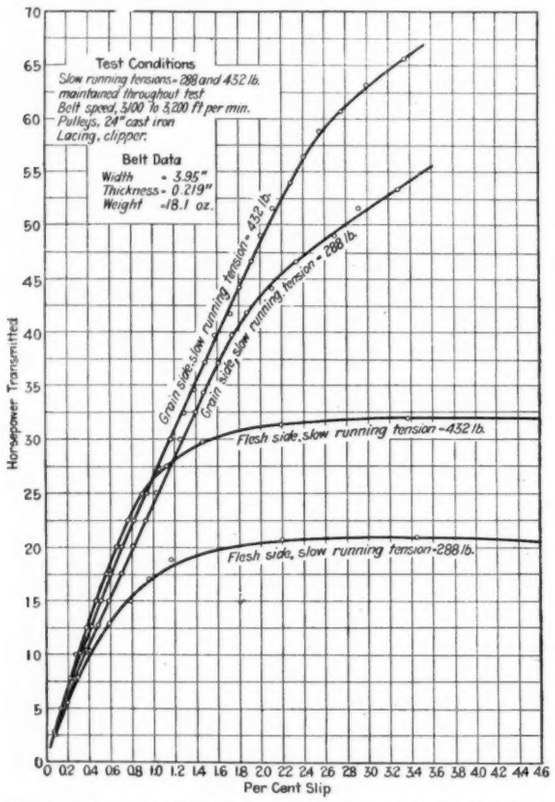
Which Side of the Belt Should Go Next to the Pulley?

Manufacturers of leather belting give instructions that the flesh side of the belt should not be run next to the pulley; nevertheless, many engineers, bearing in mind experiences had when running a given belt with the grain side next to the pulley and with the flesh side next to the pulley, feel that in general the flesh side will give the better result. In a number of tests carried out at Cornell University by R. F. Jones, research engineer of the Leather Belting Exchange, it was found that certain belts did show about the same driving capacity regardless of whether the flesh or the grain side of the belt was in contact with the pulley.

In examining one belt which gave an almost uniform driving capacity regardless of the contact side, it was observed that the flesh side of the belt improved faster than the grain side for some reason, so that for the first few hours of driving the flesh side seemed to be even better than the grain side. After a number of hours of running it was observed that the grain side began to show greater driving power with less slippage,

and it is suggested by the investigators that this undoubtedly explains the reason why many engineers believe that the flesh side makes the better contact.

It also was found in many tests that after the belt


Test Conditions
Slow running tensions = 288 and 432 lb. maintained throughout test
Belt speed, 5,100 to 5,200 ft per min.
Pulleys, 24" cast iron
Lacing, clipper
Belt Data
Width = 3.95"
Thickness = 0.219"
Weight = 18.1 oz.
Grain side, slow running tension = 432 lb.
Grain side, slow running tension = 288 lb.
Flesh side, slow running tension = 432 lb.
Flesh side, slow running tension = 288 lb.
Horsepower Transmitted
Per Cent Slip

RELATIVE CAPACITIES OF FLESH AND GRAIN SIDES OF BELT

began to approach its maximum capacity, the surface became tacky as if a belt dressing had been applied. This substance seemed to ooze out and appear on the pulleys at the low load and then become absorbed at the high load. This substance, investigators feel, was undoubtedly grease or dressing that was applied to the leather during manufacture, and it probably helps a great deal toward producing a high coefficient of friction. A level surface, such as is secured by this dressing or filling, is surely an important factor in obtaining high transmission capacity, and it seems quite likely that the amount of stuffing and the kind of grease may be of vital importance. In the illustration are shown the results of tests on a belt with 288 and 432 lb. tension. These tests indicate that the flesh side does not deliver as large a horsepower as does the grain side with a reasonable slippage. In general it may be said that the grain side will transmit from two to three times as much power as the flesh side.

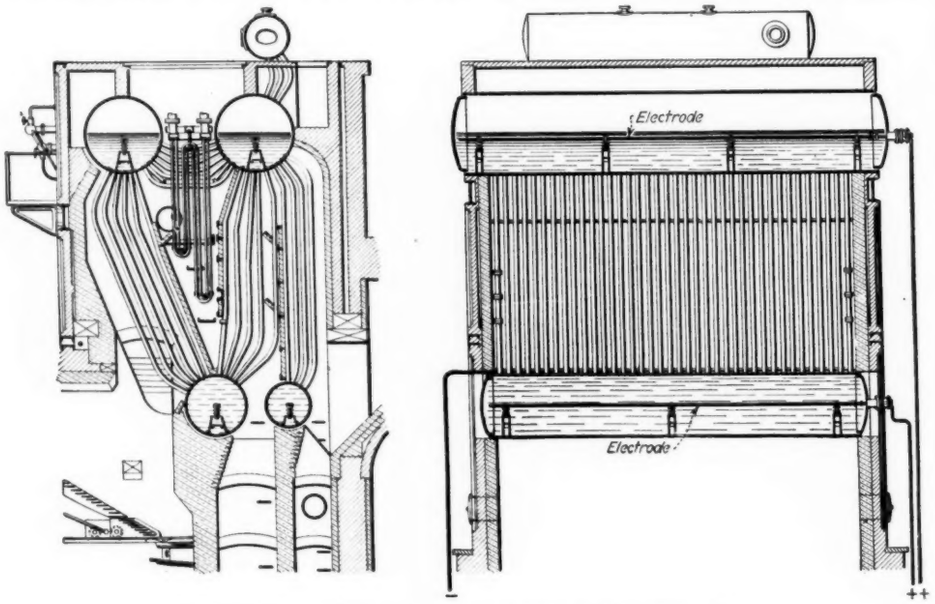
Electrolytic Protection of Boilers

According to W. Phillippi, in the October, 1921, issue of *Siemens Zeitschrift*, a successful method has been found to protect steam boilers against their two greatest enemies, corrosion and boiler scale. Careful investigations of corrosion on boiler bottoms, water tubes and condensers has proved that electrolytic action was the cause of these damages. Owing to the electromotive forces set up in the different metals used in the construction of boilers, condensers, etc., in connection with conducting water, currents circulated from these metals through the water and caused corrosion. But it was also found that in many cases stray currents from electric railways or from other poorly insulated electrical systems entered the boilers and caused corrosion.

A remedy suggested itself by employing a metal of higher voltage, like zinc and connecting it electrically to the endangered boiler, to create a counter-voltage that would prevent the flow of the corrosive current. But this method did not always give complete satisfaction, as it was impossible to regulate the current, which is necessary for different conductivity of water used.

Use of Direct-Current Effective

To use an externally generated direct current and to apply this through electrodes in the boiler, as in the figure, was found to be a remedy under all conditions. If this is done, the small but constant generation of hydrogen along the boiler walls will also prevent the formation of boiler scale. A direct voltage of from 10 to 20 volts, at a current density of about two milliamperes per square foot boiler inner surface was found to be most effective. A small resistance in series with each electrode circuit permits of suitable regulation of the current. Ordinary wrought-iron pipes are used as electrodes. Experience with this protection, extending over a period of several years, surpassed all expectations. On boats using sea water in the condensers, no corrosion of any kind was observed after months of operation, while it was necessary before installing the electrolytic protection to clean them every few weeks.



ELECTRODES INSTALLED IN WATER-TUBE BOILER

EDITORIALS

State or Federal Control of the Coal Industry

CONDITIONS in the coal industry have made it evident that some measure of government supervision of this commodity is necessary, to stabilize the industry itself and to eliminate the many abuses that the public has been subjected to by reasons of periodic fuel shortage. So far various interests have been successful in preventing the enactment of such Federal laws. However, these laws keep coming to the front, as indicated by recent proposals by Senator Kenyon, and indications are that it is only a matter of time before they will come into existence; if not Federal, then state regulation will result.

Recently, a bill was introduced in the State Legislature at Albany by Assemblyman Thomas F. Cosgrove, to create a commission to control the fuel supply within the state. This measure would give the commission control of the production, transportation, manufacture, storage, distribution and sale of coal, wood and coal products in the state. The commission would have power to reorganize at its discretion, the method of fuel distribution in every locality in the state. It is doubtful if such a bill will pass at this time, but it clearly indicates the trend of public opinion.

Enactment of public-utility laws was prevented for a considerable period, but they eventually did come into existence. Under these laws an industry has grown, which is not only one of the largest in the country but also one of the soundest financially. Therefore these laws are not so much to be feared as some of the coal interests would like to lead the public to believe. The big questions that the coal operators have to face are: Do they want state or Federal control? Do they want their industry to be under as many regulating bodies as there are states, or controlled by one uniform law administered by a Federal commission? Honest effort at this time by the coal interests, toward shaping satisfactory regulatory legislation, will be more beneficial to their industry in the future, than the present tactics to prevent the enactment of laws that are sure to become a part of our economic system.

Making "Cracked" Gasolines Conserves Crude Oil

THE man whose process will convert fuel oil into gasoline successfully on a commercial scale has been awarded a medal as an honor for this achievement. This award of the Perkin Medal by the New York City Section of the Society of Chemical Industry was made on January 13 to Dr. William M. Burton, President of the Standard Oil Company of Indiana for his contribution to chemical industry in the development of the cracking process which permits practically doubling of the yield of gasoline from crude petroleum.

Even the user of fuel oil will admit that it is a genuine service to the community to withhold this fuel oil from the market in order that the supply of gasoline for all types of internal-combustion engines may be adequately developed to meet the tremendous and increasing demands.

The Burton process of oil cracking demands high-temperature, high-pressure treatment of the crude oil instead of simple distillation for the separation of the different constituents already present in the crude. From a beginning on a small scale only a few years ago, development of the process has gone so fast that literally thousands of Burton pressure stills are now operating, with a production of about two million gallons of gasoline per day. This output represents, in fact, almost twenty per cent of the total gasoline production of the United States and Canada.

The achievement is one of importance also because it permits an adequate supply of gasoline without a great increase in the rate of exhaustion of our crude-oil reserves. Thus it is estimated that it would be necessary to use over one hundred million barrels of crude oil per year additional to get the necessary motor fuel if the Burton process were not available.

As a result of the use of the process, however, less fuel oil is made than would be produced by the straight distillation, not only because less crude oil is being used, but also because some of that which would become fuel oil by the old methods becomes gasoline when the Burton process is applied.

The saving of the equivalent of one hundred million barrels of crude oil per year is of tremendous significance, stabilizing petroleum markets and insuring more gradual change to those higher prices for all petroleum products which inevitably will come in the more distant future.

The Nations' Business Must Not Be Hindered

IN THE few months since Mr. Hoover became Secretary of Commerce, he and his able assistants have done a big work in the way of clearing away cobwebs and reorganizing the various bureaus and subdivisions of the Department of Commerce, to put them into conformity with modern business practice and to make them of real value to the American business man. The success of this work is attested by the greatly improved service rendered through the *Survey of Current Business*, the new form of the *Commerce Reports* and other extensions of the Department's activities. Not many of the general public know of these improvements, and even less have any knowledge of the intimate relations that have been established between the Department of Commerce and the one hundred and twenty-seven trade associations with which it is in contact. Perhaps a somewhat larger part of the public knows of the ninety committees of citizens that are in close touch with the Department, because these committees include, it is estimated, three hundred and fifty thousand engineers, merchants and manufacturers who receive active help and assistance from the Department of Commerce.

That this work has not been carried out without great

difficulty is indicated by the fact that lack of funds has caused, in the Bureau of Standards alone, during the last five or six years, a turnover of about fifty per cent. The reason for this condition may be seen in a comparison between the salaries paid in the Department and those paid in comparable business positions outside the Government's organization. Directors of bureaus receive six thousand dollars a year, whereas the same men in business would be worth from fifteen thousand dollars to twenty-five thousand dollars. Assistants in bureaus are paid three thousand five hundred dollars to four thousand five hundred dollars, as compared with the ten thousand dollars to fifteen thousand dollars that they could make in business. Division chiefs get from two thousand four hundred dollars to three thousand dollars, although they could make four thousand dollars to five thousand dollars if they worked for more generous employers than the Government. These are not theoretical figures, but are from actual examples in the Bureau of Standards and the Bureau of Foreign and Domestic Commerce. Thus, the Department of Commerce is in disadvantageous competition with private business in finding men of ability.

In order to carry on its enlarged activities the Department now needs an increase of some seven hundred and fifty thousand dollars, which is included in the budget agreed to by the Budget Director, and which is now being considered by Congress. Today, as never before, the American business man is looking to the Government for assistance and support, and if he would secure that assistance he should not be slow in letting Congress know that he will not tolerate a niggardly policy toward the full program that ought to be carried out for the better conduct and increased expansion of American business.

Wireless Lectures—Possibilities and Obstacles

NEWS coming from New Jersey that an N. A. S. E. local has had a lecture broadcasted to it by wireless telephone, as told elsewhere in this issue, gives new interest to the growing popularity of the radiophone. This device has become increasingly prominent in the last few months, and some have even gone so far as to class it as a serious competitor of the phonograph and the motion picture, as a means of personal entertainment. Its use by an engineering society, however, is a new wrinkle.

The underlying reason for the success of the wireless telephone is that it makes possible the "broadcasting" of news, recitations, music or anything else that is desired by a large number of people who would otherwise be unable to hear it. If they gather together in one room, the need for any kind of telephone largely disappears, and the speaker or musician might better be brought to them in person. It is possible by suitable apparatus to amplify the message as received so that a considerable audience can hear it, but the difficulties of doing so increase greatly with the distance over which the message is transmitted, and the operation becomes too costly to be practical. The wireless telephone, in its present state of development, is best used by a large number of small groups of persons, each with a separate receiving set. That means that the subject and the messages must be of general interest.

The lecture given before the N. A. S. E. in New Jersey was, of course, of interest to the engineers, but not to the general public. Likewise, any lecture that an engineering society would be likely to want to receive by wireless would not interest a large part of the public, and therefore would not meet with favor from those who are at present engaged in broadcasting, because their object is to please the public by giving it what the majority want.

But whether or not it proves practical to transmit lectures to single groups of engineers, a more interesting suggestion comes from New Jersey to the effect that news of national conventions might be broadcasted to local associations and smaller groups within the range of transmitting capacity. The idea is a daring one and seems not only to have wonderful possibilities, but also to be within the limits of practicability.

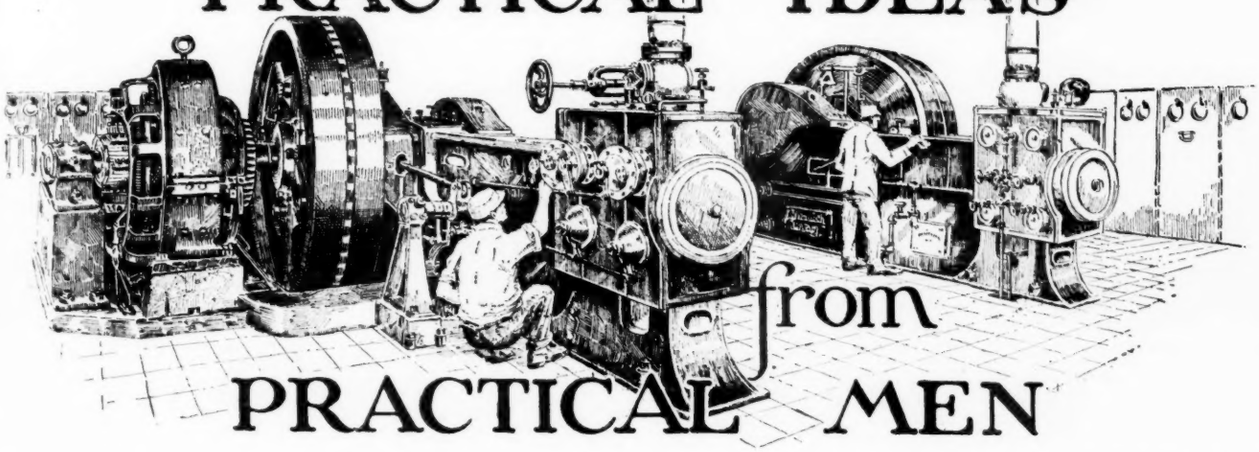
What would such a change mean? One can only guess. Undoubtedly, the attendance would be cut down greatly, but probably the number of listeners would exceed, many times over, the number in personal attendance at the most successful conventions. With a much larger audience to hear them, the delegates would probably put more care and thought into their remarks, and better judgment might result from the proceedings. On the other hand, such a convention would fail in one respect that is vital; it would afford no opportunity for men from different parts of the country to get together and exchange news, discuss their work and broaden their views of current affairs.

A Premium on Inefficiency

WHAT is a fair and reasonable rate for electric service is a problem that many conscientious men have attempted to solve, but it is still with us, a never-failing source of free-for-all argument. As new conditions arose, various factors, in addition to the kilowatt-hour charges, have been introduced, such as maximum demand or readiness-to-serve charge, low power-factor penalty charges, etc. During the war, when coal prices were soaring, the fuel clause was introduced in power contracts, as a sliding scale whereby the charge for power might be made to vary with the price of coal. With a basic price for coal a certain charge was made for power, and for each increase in the cost of coal an increased charge was made for power, or for a decreased cost in coal a reduction was made in the power charge to the consumers. There are few who will deny the justification of such a charge, but how much it should be with fairness to the utility and the consumer is a question open to discussion like other factors that affect the making of rates.

Recent investigations have shown some peculiarities in the coal clause, one of these being that in some cases it was more favorable to the utility the higher the price paid for coal. As the coal clause was evolved, it was for the purpose of passing on to the customer a part of the increase in the price of fuel above a certain established minimum, not more than the increased cost as it has worked out in some cases. Whenever all the increased cost of fuel or more than the increase is passed on to the consumer, the coal clause becomes economically unsound by placing a premium on inefficiency. It is doubtful if conditions exist in general where the coal clause works out for the utility in favor of high-priced coal, but the fact that such conditions have been found makes it imperative for the public-service commissions and others interested to investigate and correct this wherever it has been established.

PRACTICAL IDEAS from PRACTICAL MEN



Personal Element as Affecting Power-Plant Instruments and Efficiency

A serious problem that confronts the power-plant manager, the efficiency engineer and the manufacturer who puts on the market instruments or devices for recording, indicating or measuring the efficiency and performance of power-plant equipment and methods is the attitude of the operating force toward this equipment and the maintenance of their continued interest.

Frequently, it is the experience where efficiency instruments are installed, adjusted, put in service and operated faithfully for a month or two or perhaps longer, that then the plant operators either lose interest or decide that it is too much trouble to record and digest the readings; or trouble is encountered with the device and confidence is lost in its accuracy and gradually its use is discontinued and the apparatus is abandoned.

Indicators, recorders and measuring devices of various kinds stand inoperative in great numbers, discarded and often discredited, because little or no intelligent attention or study has been made of the proper cultivation of the ordinary plant operators who are called upon to use and manipulate them and who must "sit up with them" and keep them going. Too often their interest and spirit of co-operation have not been aroused, and as a matter of fact the operator often becomes antagonistic because of this oversight in not properly handling the problem from his viewpoint.

In the large central power stations the uncertainty from the "personal element" factor is largely overcome or guarded against because these organizations can afford to hire technical assistants who are acquainted with the design and purposes of the efficiency equipment and whose duty it is to see that the various instruments are kept in service, in good accurate operating condition, and that the readings are taken continuously, and then that the information thus secured is studied and used to advantage in rectifying wasteful conditions.

But in the average industrial power plant this expert supervision is not always possible or practicable, and therefore the success or failure of the use of such apparatus lies in the interest and intelligence expressed by the operating force.

Where a power-plant owner has invested money in instruments of various kinds, he should endeavor to secure the fullest benefit from them by enlisting the interest of his force in their proper care and operation. Just how this can be done depends on the conditions and personalities in each particular case. Usually, the first essential is to give the operating force the chance to become converted to the use of the instruments before they are purchased; that is, get them "sold" on the use of the equipment before it is turned over to them.

Often the offering of a bonus for turning in complete records and digests of power costs provides the necessary incentive; in other cases a bonus on increased over-all efficiency or capacity does the trick; sometimes the desired results can be obtained by insisting on the compilation of a monthly data form bringing together all the various readings and information in such shape that comparisons may be instituted and shortcomings noticed.

In every case, however, the full realization of the benefits will not be attained until the operator is made to realize the value of the instruments and the information they supply, and this realization will be complete only as the education and intelligence of the operating force is broadened. For this reason, where a plant is equipped with recording instruments, the owner should make it a point to supply the man in charge, who in turn can also post his understudies, with all the means in the way of textbooks, engineering papers and catalogs, that will enable him to secure a proper insight into the reason for the use of such equipment.

The impression that these power-plant instruments are installed to act as a check or watch on the work that is being done, is often entertained by operators, who do not seem to realize that primarily the installation is made to assist them in securing better efficiency and hence making their services of greater value to the management. In every case the proper use of a power-plant instrument should redound to the advantage of the operator unless he is prejudiced by the idea that it was installed to keep his nose to the grindstone.

Summed up, power-plant instruments of various kinds are profitable investments only when they are kept in continuous accurate operation and when the operating force displays sufficient interest and intelligence to take the data supplied by the instruments and thoroughly digest and analyze it, with the idea in mind of spotting and remedying wastes or losses. To secure this interest and co-operation is the problem that must be solved in each case by the manager, before the benefits possible will be reaped to the fullest extent. M. A. SALLER.

Philadelphia, Pa.

Brine Cooler Froze Up

Some time ago in a small plant where a 10-ton refrigerating machine was used to carry a freezer, the brine cooler froze up. Sodium chloride, which has a fairly high freezing temperature, was used for brine instead of calcium chloride. The engineer asked me to come around and see what I could do, and on arriving I found that the centrifugal brine pump was frozen up and would not work.

I immediately turned on the condensing water and started the compressor turning over very slowly. When the regulating or expansion valve was opened, the ammonia liquid flowed into the coil much faster than the compressor could remove the vapor, and as a result the coil pressure and boiling temperature rose. The fairly warm liquid ammonia from the receiver immediately thawed out the coils without damage, and the brine pump could be started. Although the pump was handling a rather bulky solution of ice crystals and salt solution, it was able to keep up the circulation. I suggested the use of 24 per cent calcium chloride solution, which has a freezing temperature of —17 deg. F.

The engineer could not understand how it was possible to thaw out the brine by running the compressor. I explained to him that the hot ammonia liquid from the receiver entered the shell cooler at about 80 deg. F. and, being much hotter than the brine, of course warmed the latter until the solution was in condition to be handled by the pump. D. L. FAGNAN.

New York City.

Two Emergency Engine Repairs

The piston of a small vertical engine was fitted with a concave follower plate, as illustrated at *A*, Fig. 1. There were no follower bolts, as the nut *B* was intended to hold the piston rod in the piston, also to clamp the follower plate in place. This is a weak form of construction, especially when the follower plate is made of

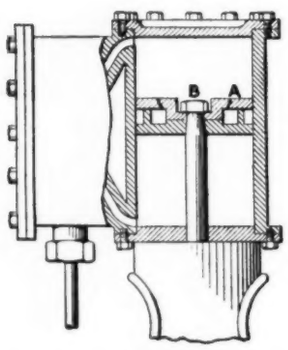


FIG. 1. WHERE FOLLOWER PLATE CRACKED

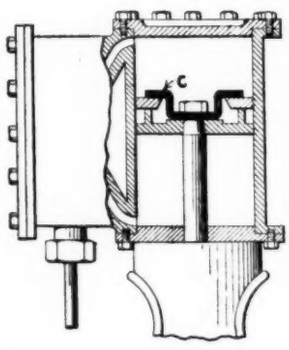


FIG. 2. HOW THE REPAIR WAS MADE

cast iron. While carrying a heavy load, this plate failed by cracking as shown, leaving a circular piece still held by the nut. The external ring flew out of place and liberated the packing rings, but did not break them.

The engineer secured a piece of flat iron, about 2 x ½ in., and bent it into the shape shown by *C*, Fig. 2. Drilling a hole in the center of it, he put it over the end of the piston rod and by means of a socket wrench screwed the nut down tight. Fortunately, this engine had a large clearance, so that this extra iron did not come in contact with the cylinder head. This makeshift enabled the engineer to keep the engine in service until a new follower plate could be procured.

In another case the valve-rod extension of a small vertical engine broke, as illustrated at *D*, Fig. 3. As this was in the guide, it seemed to be necessary to shut down until a new part could be procured from the manufacturers, but as the delay would prove both annoying and expensive, the engineer had the two parts filed out, as shown at the right. Two holes were then drilled and countersunk. When close-fitting rivets were inserted and headed down, the part proved satisfactory for several days, until a new one was procured. Of course this dressing shortened that particular part, but by not screwing it so far on the rod as formerly, the proper length was secured to operate the valve. W. H. WAKEMAN.

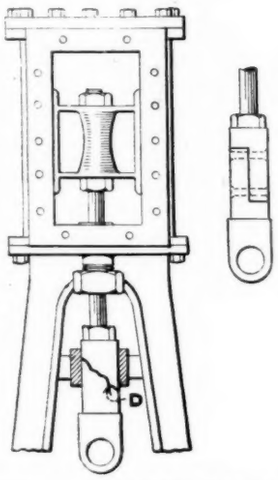


FIG. 3. CRACKED VALVE-ROD HEAD AND REPAIR

New Haven, Conn.

Motor Would Not Reverse When Field Current Was Reversed

Where direct-current motors of medium and large size are concerned, it can be predicted how they should act under given conditions. However, small motors may hold a surprise, as is illustrated by the following experiences:

In a certain instance it became necessary to reverse the armature rotation of a small shunt-wound motor used for driving a fan. Following a common practice, the leads of the field windings were interchanged in order to effect the desired reversal, but the armature turned in the same direction. The interchanging of the leads was repeated in order to make certain that no mistake had been made either in noting the direction of rotation of the armature or in reversing the field leads. However, no mistake had been made in either. Investigation of the field coils then disclosed that one of them was open-circuited and that the motor had been operating under this condition for a considerable period. The field coil was repaired and the operation of the motor became normal.

In another instance a small motor used for driving a ventilating fan burned out its armature, due to bearing wear permitting the core to go down onto the polepieces. The armature was rewound, but before it was tried out a field coil was found to be grounded, and both coils were removed for repair. When the motor was put back into operation, the armature got very hot if permitted to run for more than a minute or two, and the brushes would spark. On connecting an ammeter into the circuit, it was found that the current was considerably above normal full-load rating, while the speed was below the rating corresponding to full-load current. Thinking that the trouble might be due to an error in

connecting the armature coil leads to the commutator, it was proposed to try reversed rotation. On reversing the armature leads, however, the rotation remained the same as before reversing the leads. This trouble could not be a case of open-circuited field coils because the motor was series-wound and an open in either field coil would have interrupted the motor current.

When the speed of the motor was taken, there appeared to be considerable attraction between the end of the armature shaft and the point of the speed counter, thus suggesting a strong stray field. This would indicate that the field coils might be connected to make both the polepieces the same polarity. Accordingly, the armature was removed, the field coils energized and the polarity of the polepieces tested with a wire nail and found to be opposing each other. On reversing one of the coil leads, operation became normal. Had the mechanical load on this motor been a little less, it might have operated indefinitely with reversed coils, just as the motor of the preceding incident operated with an open field circuit. However, such conditions can exist only on small motors where the load is of a suitable value.

E. C. PARHAM.

Brooklyn, N. Y.

Light Versus Heavy Firing

Years ago, when a fireman took hold of a new job, one of the first things he did was to open the check slides in the firedoors and place a folded newspaper over the opening to test the draft. If it was strong enough to hold the paper from falling to the floor, it was considered good and the fire was handled to correspond with it. It was not at all unusual to see a husky fireman shovel in from 25 up to 40 scoops of coal at a firing, and each scoopful would weigh from 20 to 30 lb. This was usually fired into one door, or on one side of the furnace, and allowed to "choke up" for 10 or 15 minutes. Then the slice bar was brought into play and the whole amalgamated mass was ripped up and oftentimes turned upside down—any way to get it to burn—and when it got well to going the other side of the furnace received the same treatment. In the meanwhile the black smoke was rolling from the chimney and the heat units were never given a second thought.

Finally, as the use of bituminous coal increased and the smoke became a nuisance, investigations and experiments were undertaken, in the effort to abate the smoke, and it was not long before the fact was revealed that the smoke and also the fuel costs could be greatly reduced. From that time to the present one of the greatest studies in the engineering field has been improved methods of combustion—and the end is not yet.

FIRING LIGHT AND OFTEN

The first experiments tried were with lighter fires and more frequent periods of firing, and the results led to the fixing of that old, reliable (?) phrase, "Fire light and often," and at the time and under the conditions that then existed, the rule was a good one. But as the size of the individual units increased and the methods of setting boilers changed and chimneys grew higher, it ceased to be as effective as when it first became a rule in the engineer's code. Time has proved that the good fireman of 25 years ago, who could keep 60 to 100 lb. of steam on a return-tubular boiler having 16 to 25 sq.ft. of grate surface, by firing 4 to 6 lb. of No. 1 Georges Creek, New River or Pocahontas coal per square foot of grate per hour, firing at 10-minute intervals and spreading the fuel in such a manner as to keep a bright fire all the time, would either fall down on the job or kill himself in a short while. If he attempted to follow the same methods today in a plant, he would be required to burn 15 to 20 lb. per sq.ft. on a grate surface of 49 to 56 square foot.

But it can be done and done fairly easy, provided the man uses his brains; and it can also be done with but little loss of fuel if the proper method is followed. Just to give an idea of how to begin, I will describe one or two of the methods that have helped me to success as a master fireman and an engineer of, to say the least, average-plus ability.

WORKS IN A COUNTRY STREET-RAILWAY POWER STATION

To begin with the old-fashioned method, where steam and a lot of it was the first consideration, I will go back to a country street-railway power station. The plant was new and had been in operation less than a year when I went there and started in to make "fog." There were four horizontal-tubular boilers, 6 ft. diameter, 20 ft. long and each with ninety-eight 3½-in. tubes. The working pressure was 125 lb., the boilers were hand-fired and were set about 40 in. above the grates, and each grate had 42 sq.ft. of surface. The slave of the shovel had to wheel his own coal and keep up the pressure in two, three, and on big days all four, boilers, and just to keep from getting lonesome he had to clean the fires at noon and wheel out the ashes. It was no job for a crippie.

I was young and foolish and had more strength than brains, so I went to it. Nevertheless, I dropped 22 lb. in weight the first eleven days I was there, and by that time there was not much but skin, bone and muscle left, but I did not mind that. I was the twenty-eighth man to tackle that job in less than a year, and all the others lost the steam pressure at some time or other during their stay. I was considered "some" fireman in those days, and I had no intention of losing my reputation in that particular plant until I was down on the floor.

Right there I began to hunt for ways and means to make good. I was not long in discovering that the draft was very good, almost too good. Then I tried all my favorite fires, of 8 to 10 in. thick and nearly level, but slightly heavier at the bridge wall, as the back end would burn out faster than I could keep live fire supplied there, and I always made it a rule to keep the rear end of my fires bright. I began to experiment with slightly heavier fires until I finally had one that was fully 24 in. thick at the bridge wall and evenly sloped to the firedoor, where it was about 6 in. in depth. Now here is where both light and heavy firing come in at the same place and at about the same time.

When cleaning fires and building up the new ones, it was nothing unusual to shovel in from 600 to 1,000 lb. of coal at one firing, and most of this was placed well to the rear, and the other side of the furnace was usually at white heat or near it. By this method the gases were consumed and but little black smoke escaped up the chimney. After both sides of the fire were cleaned, a good body of live coals was built up and shoved back to the bridge wall and then covered with green coal, all it would stand without showing too much smoke at the chimney top. I continued to do this until the desired depth at the bridge wall was had, and from then until the end of the day I seldom if ever shoveled

in more than two scoopfuls in each door at any one time; I fired the doors alternately.

By this means I was able to do the work ordinarily done by two or more men, and except at cleaning time I was kept busy all the time, and if, as sometimes happened, an extra car or two was put on the line the fires were ready to do their work and at once. My daily record was twelve tons of coal in twelve hours, wheeled from forty to one hundred feet, weighed and fired; and besides that I cleaned the fires and wheeled out from six to twelve barrows of ashes from each fire. The chief told me that I had saved my wages the first day I ever worked there, and what I saved after that when I had got wise as to how to handle the job, I have still to learn. That is a sample of what some would call heavy firing.

I will relate another instance of a different job and different conditions. About three months after leaving the plant referred to, I was in a city near Boston. I had received my third-class engineer's license and went to a small textile mill to fill in while the regular engineer was sick. Here I found one horizontal-tubular boiler 5 ft. diameter and 16 ft. long, which supplied steam for a 50-hp. automatic-cutoff high-speed engine, heat for part of the mill and also steam for two 1,000-gal. kettles. The plant was well kept and the load was even and not too heavy, but for all that my first two days there gave me the worst dose of worry and fret I had ever experienced. The draft was not good and, as usual, I started out with a fairly light fire about 6 in. thick. The fuel was one part good soft coal and three parts screenings. At that time I had had but little experience with screenings, and although I was wise enough to fire light and often, it was all I could do to keep the plant going the first two days. Early in the morning of the third day the superintendent returned from a business trip, and finding out that the regular man was ill, he at once came out to the boiler room to see what sort of "gink" was in charge. He found me, busier than a one armed paperhanger with the seven-year itch, steam down 15 lb. lower than it should be and no signs of it rising.

Takes a Lesson from the Superintendent

He gave me a smiling good morning and cast a glance at the gage and water glass, and remarked, "Well! are you up against it?" I had to admit that he was right. He then wanted to know if I would take a little advice in the right spirit, and he was promptly informed that he was talking to someone that would try anything once, and more if he thought he was on the right track. "Good boy!" said he. He opened the firedoor and looked inside and said, "Why, man, you have just three times as thick a fire as you need there," and I looked at him in astonishment. He then said, "Now don't put in any more fuel until I come back and I will show you something that you will not believe if I tell you." He left the boiler room and in a few moments returned wearing a pair of overalls and gloves. He picked up a small rake, made from part of a steel garden rake welded to about seven feet of ½-in. pipe and went through that fire like a fine-tooth comb. He picked out several clinkers about as large as a doughnut, leveled off the fire and sat down, took out his brier pipe and filled it and smoked for ten minutes or so and then began combing the fire again.

This performance was repeated for upward of thirty minutes, and by that time there was not two inches of fire in that furnace and I was looking for a shutdown, when all at once he turned to me and asked what mixture he was using for fuel and I told him. He said that was right and opening the firedoor he threw in just two small scoopfuls of the fuel and turning to me told me to look at the steam gage. I did so and may I never see another boiler if the steam wasn't rising, and it continued to rise till the damper closed.

Well, to shorten the story, he sat around there for two hours longer and watched me practice the lesson he had taught me while he expounded the theory of what I have since learned to call combustion. Then he went back to his office, and for the next seven weeks I had the biggest snap I had ever had in a steam plant or ever expect to have.

Since then I have been in many plants of all sizes and shapes and in all sorts of condition, and I have come to the conclusion that while the old rule of "fire light and often" still holds good in the small plants that are not overloaded, it should be used with judgment. On the other hand, I am strictly opposed to heavy firing in the broad sense of the word. Modern developments have made it possible to get more work out of the same amount of fuel at a less expenditure of brawn and muscle than was possible twenty-five or thirty years ago, and the man who has to fire a small plant, or for that matter any plant, by hand today, will be well repaid by taking a day to consider the action of a mechanical stoker-fired furnace.

As a matter of fact, the wise owner will do well to install the hand-operated stokers provided his plant is not large enough to warrant the use of mechanical stokers. Hand-firing has had its day and has served its purpose, but it will soon be a thing of the past with all up-to-date owners who can see an inch beyond their nose. They are a necessity and an investment, not an expense.

W. E. Chandler.

N. Grafton, Mass.

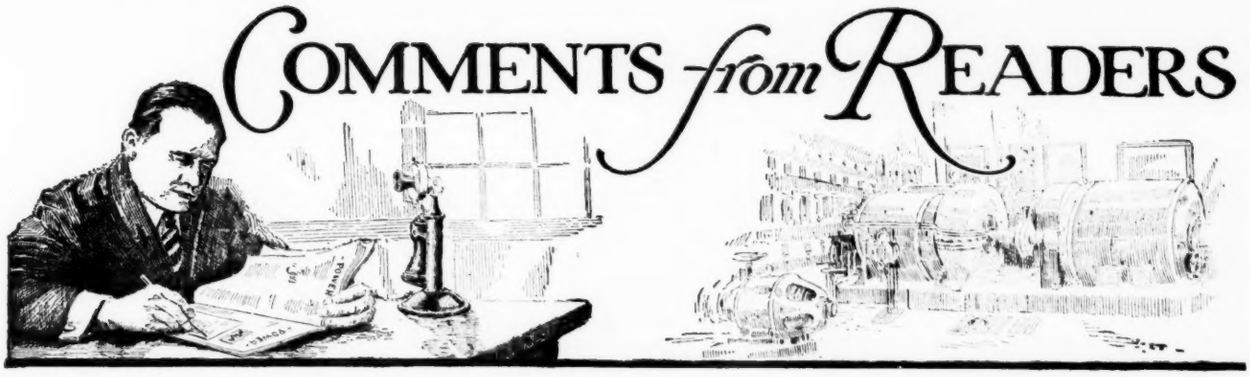
Simplifying Locating Troubles on Electric Circuits

Probably everyone whose duty calls for the care of electric circuits has at some time been required to locate trouble on long lines or lines from which numerous branches are tapped, and has been greatly inconvenienced at the delay caused by the necessity of disconnecting soldered joints. Such a line may supply service to a process that will suffer from any protracted shutdown. It is not uncommon for opening the line in order to locate the fault, to require more time than the actual work of clearing the trouble.

To lessen the time consumed in this work, a standard of construction could be adopted that would considerably reduce this loss; in many cases the reduced loss of production would pay for the added cost of installation when the first case of trouble appeared, by reason of the quicker return of the line to service. This construction for both open and conduit work may take the form of terminal lugs bolted together at all branches or at intervals in long lines. The construction may be elaborated to the extent that some form of branch or main-line cutouts may be connected in the circuit, in which solid copper would take the place of the usual fuse, the installation being arranged so that in the event of trouble the fault may be readily located, with a minimum amount of preparatory work.

Harold R. Hutchinson.

Cambridge, Mass.



Disagrees with Some Observations on Lubrication

Having noted Mr. Boehm's comments on the subject of lubrication (page 35, issue of Jan. 3) I offer the following comments, which may make clear to Mr. Boehm the matter of oil acidity and its relation to emulsification.

All oils in use have a tendency to develop petroleum acids. These are different from fatty acids, to which Mr. Boehm refers, as well as from the mineral acids, such as sulphuric. Mineral acids are soluble in water, but petroleum acids are not, and their presence in an oil makes the latter more susceptible to the formation of emulsions.

The cheap oil, owing to its method of manufacture, develops petroleum acids more rapidly than the high-grade oil. These acids, in turn, make it more susceptible to emulsification. H. G. HAWES, JR.

Mt. Vernon, N. Y.

Using Exhaust Steam in Burning Buckwheat Coal

On page 689 of the Nov. 1, 1921, issue of *Power* G. W. Harris tells of his experiences with clinkers in burning small anthracite, and mentions that his steam consumption, using jet blowers, was only about 2 per cent. I question this statement, for while turbine blowers are known to consume only 2 per cent or where conditions are unfavorable, as much as 2½ to 3 per cent, the steam jet takes several times as much steam. The guarantees made by manufacturers of one of the most efficient kinds of a jet—the multiple steam jet—show power consumptions of over twice that of turbine-propelled blowers.

In addition, the steam exhausted from the turbine blower can be piped back into the heating system, which cannot be done with the jet blower. However, if trouble is experienced with clinkers, the steam exhausted from the turbine can be sent into the ashpit instead of into the heating system and that will be found just as effective as steam jets for softening the clinkers.

New York City. LLOYD M. KEEK.

Why Not More Designers?

The editorial in the issue of Dec. 20, 1921, "Why Not More Designers?" discussed at the A.S.M.E. meeting by F. C. Pratt, touches on a question uppermost in the minds of a large part of the engineering profession.

A young engineer entering the field of design today, is placed in a rather disagreeable position in relation to the engineer entering the more lucrative industrial and commercial field. The young engineer, on entering a position, sacrifices the monetary compensation in favor of practical experience. As he advances in practical knowledge, he naturally expects the monetary appreciation to keep pace. It does up to a certain low limit, but this limit is a low wage in relation to that paid in the commercial field. Now why blame an engineer for leaving the field of design?

Three years ago I left the field of design to take a position in the industrial field. I find that the money appreciation is larger, the work less stringent and more healthful, and the necessary qualifications are an equal division of technical and practical training.

As the blame for the decreased number of designers in the field today lies with the manufacturers, I hope that some action will soon be taken to remedy a situation that should never be as it is. The young engineer will do well to watch developments for the next few years, to be sure that the field of design receives from manufacturers the consideration that it deserves. Then we will have conditions reversed; the designing engineer will receive the monetary appreciation that the industrial engineer is receiving today. J. F. COEN.

Covington, Ky.

What Caused the Circuit Breakers To Open?

In the Dec. 13, 1921, issue B. Jones discussed the opening of an oil circuit breaker on a rotary converter, and advanced theories as to the probable cause of the circuit breaker failing to stay closed in this particular case. The fact that the oil circuit breakers opened three times in succession does not lead me to believe that this condition was caused by the presence of the residual field in the transformer core. A large rush of current due to the residual magnetism having a polarity opposite to that produced by the incoming current, while not impossible, is, I believe, infrequent.

It has been my practice in starting synchronous converters to close the high-tension circuit breakers first, then to start the converter with the starting switches. In stopping the machine, the direct-current breaker was tripped first and the starting switch pulled out. When the voltage dropped to a certain value, the field break switch would be opened and the high-tension oil circuit breakers tripped last. There is no doubt, however, that Mr. Jones' idea in regard to destroying residual magnetism is commendable.

Utica, N. Y. C. R. BEHRINGER.

Burning Anthracite Mine Waste Efficiently

An interesting description of certain tests conducted in the Mount Vernon plant of the Philadelphia Rapid Transit Co. is given by O. M. Rau, in the Nov. 29 issue. The article is replete with photographs and drawings referring to the equipment as at first installed, but aside from quoting figures on one test run with equipment furnished by the Ground Coal Engineering Co., of Chicago, it makes no mention of numerous salient facts surrounding these test trials.

Fig. 1 shows a design prepared under the writer's direction to install two 10-in. "Multi-Mix" burners on the same dutch oven as had been used in the previous tests. It will be noticed that the distance from the head of the boiler to the outside wall of the dutch oven is 7 ft., ½ in. Mr. Rau and other engineers connected with the Philadelphia Rapid Transit Co. raised the objection to the original installation that the large dutch oven occupied all the working space in front of the boiler and they desired to reduce the size. Reducing this distance to 3 ft., 8 in. accounts for the combustion space of 800 cu.ft. instead of the 1,542 cu.ft. first used.

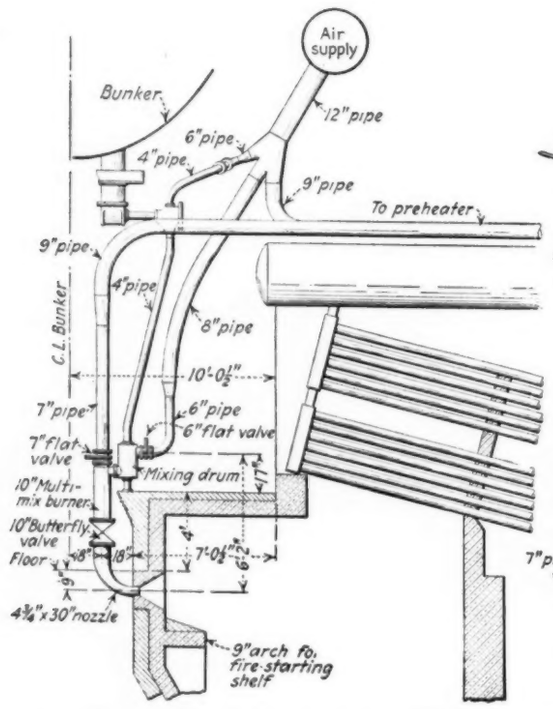


FIG. 1. ORIGINAL LAYOUT OF PULVERIZED-COAL BURNER PIPING FOR 6-OZ. AIR PRESSURE

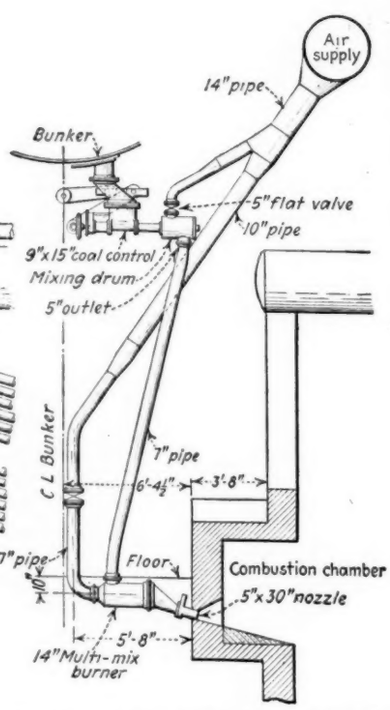


FIG. 2. PIPING CONNECTIONS PROPERLY SIZED FOR LOWER-PRESSURE AIR

It is not considered by the writer that the tests quoted are representative of the best results of which the revised installation is capable. He has not had opportunity to calculate the efficiencies of these various runs, and it is not claimed that they in any degree represent what is possible under suitable operating conditions.

Mr. Rau's article neglects to mention that the burners as installed were not of the size and capacity recommended for the service indicated, but were shipped and installed on the information that 6 oz. air pressure would be employed. After the burning equipment was set up, it was found that the plant engineers desired to operate the low-pressure fan at 1½ oz. The pressure actually available at the burners hardly exceeded 2 in., and it was not possible to operate satisfactorily these two 10-in. burners, designed for 6-oz. pressure, at such a low pressure. In fact the pipe lines would not carry a sufficient volume of air for the coal at this pressure, and it became necessary to make an opening near the hearth about 4 in. high and 3 ft. wide when operating at the higher ratings. All air thus admitted to the furnace sacrificed to that extent the fundamental principle of the equipment whereby all the air required for combustion should be fed into the apparatus and therein thoroughly mixed with the fuel.

Furthermore, the fundamental design of the equipment calls for the mixing operation to be performed in two stages—one in the drum attached to the end of the feeding screw and the other in the burner proper. As it was desired to use the existing feed screws, a second sacrifice from correct conditions had to be made in attempting to operate the preliminary drum in a vertical instead of a horizontal position, and it was shown that no mixing effect could be had in this drum in such a position, so that all of the first-stage mixing was eliminated. Furthermore, the conditions required for even mixing and even firing of the furnace involve a steady delivery of fuel by the feeding screw, and the shutoff gates on the screw in question operated with such erratic irregularity that it was not possible to give an even flow of fuel to the apparatus.

Mr. Rau's statement regarding the amount of oil required to ignite the coal burners is interesting, but he neglects to mention that with the original installation one hour or more of oil firing was required prior to turning on the coal. In fact the furnace had to be heated up with oil to not less than 2,100 deg. before it was possible to light the coal. On the other hand, with the latter equipment, only about 10 gal. of oil and an igniting temperature of 1,100 deg. is required in the furnace to light the coal stream, this being due to a specially designed ignition hearth and to the better mixture of coal and air.

It would be interesting if Mr. Rau would tell how the firing of the original installation with oil for one or two hours out of the total twelve of the test would bear on the coal consumption and apparent efficiency indicated in the tabulated figures, as compared to the firing of only 10 gal. of oil over a period of possibly 15 min. with the revised equipment.

Near the end of his article, Mr. Rau states that the burned-out ash is accounted for by the effect of the ignition chamber, but this is true only when taken in connection with the effect of a complete, even mixture. He also states that the lower efficiency is due to the failure to complete combustion of the fuel in the smaller chamber. It can only be stated that the character of

gases produced does not indicate any lack of complete combustion, since the equipment operated invariably at high CO_2 ratings ranging from around 15 to 16 per cent with the other gas conditions satisfactory.

The writer is aware that the statement has been made that certain of the unconsumed fuel would be carried up the stack and would not be reflected in the CO_2 content of the gases. If this hypothesis be true, it would obviously apply in a greater degree to the original installation where a 10-oz. pressure was employed as compared to a maximum pressure of air at no time greater than 3½ in. when operating with the revised equipment.

When the writer first agreed to go into this trial test, it was understood that a second series of tests would be made, using an air preheater. It yet remains to be seen what effect mixing all the air for combustion with the fuel, either cold or preheated a normal amount, will give on the small furnace used in this case.

In order to utilize the low air pressure as desired, it is necessary to use larger burners, at least 14 in. or 16 in. diameter, depending on the capacity ratings desired, and these should be operated preferably in the horizontal position, as indicated in Fig. 2, although the burner itself may be set vertically, as indicated in Fig. 1, It will be noticed that Fig. 2 embodies complete controls, with the preliminary mixing drum properly mounted on the feed screw, and air lines of sufficient size to furnish the correct volume of air for combustion at the low pressure desired for the best operation of the apparatus and furnace. This equipment is adaptable for use with low pressures, which are in fact preferred, but it is obviously unfair to quote tests made with apparatus operating under pressure conditions for which it was not designed and make no mention of the facts involved.

M. W. ARROWOOD, Executive Engineer,
Chicago, Ill. Ground Coal Engineering Co.

Short-Circuit in Armature Caused Lights to Flicker

I have been much interested in the various suggestions offered in *Power* regarding Mr. Groom's query as to the cause of lights flickering. An experience that comes to mind may be helpful, although a repetition of the circumstances that led up to the trouble is hardly probable. The generator responsible for the trouble was part of a motor generator set that had previously been subjected to a severe short-circuit on a feeder. After the short-circuit had been removed and the set was again started, the lights flickered. The first thought was that the armature had suffered from the unusual load. Close examination showed that the insulation between turns on several coils had been destroyed. While the armature was running, the conductors were caused to vibrate and come into momentary contact with each other. This developed short-circuits in the coils which caused the lights to flicker at a very high rate, almost as if they were operating on 25-cycle alternating current. Under such conditions excessive sparking at the commutator will confirm any suspicion of armature defects provided the ammeter indicates a fairly constant load within the range of the machine.

The trouble was caused by a lightning discharge coming in on the system and producing a flash-over in a distribution box on the end of a 400,000-circ.mil feeder. As fate would have it, the fuses protecting the motor generator set were in poor condition, as they had been refilled so many times that the cases were badly carbonized. When they were subjected to the strain of rupturing the heavy current of a short-circuit on the feeder, the cases were exploded and the arc held over. When I arrived in the motor room shortly after the trouble, the arcs were still established, and one look at the ammeter showed the needle to be off the scale. To have opened the generator switch under this condition would have produced an arc that probably would have proved disastrous for the switch and also to the one that opened it. Fortunately, the proper thing was done; that is, the oil switch on the induction motor was tripped. When this was done, the load current of the motor was sufficient to cause considerable oil to be thrown out of the switch tank.

This experience should not be taken as an argument against the refillable fuse, but as a warning that the casing of these fuses should be watched and replaced when found to be in poor condition, due to a number of blowouts. Failing to do this on the generator in question resulted in expensive repairs, which might have been avoided if proper care had been exercised in fusing the circuit. Proper electrical protection is comparatively cheap, but the lack of it may prove exceedingly expensive.

HORACE STEINHOFF.
Stratford, Conn.

Valves in Water-Column Connections

I have observed several interesting articles in *Power* recently on the subject of valves on water-column connections. I have had experience with gage cocks causing trouble that could not be repaired. Particularly is this true of the old ball gage cocks with rubber disc. The disc blew out and the cock leaked so badly that it was necessary to let the boiler die down merely to replace the disc, because there was no valve on the water-column connection between the column and the boiler. This condition was corrected by installing a gate valve of the outside-screw and yoke type, which I understand is prescribed by the A. S. M. E. Code.

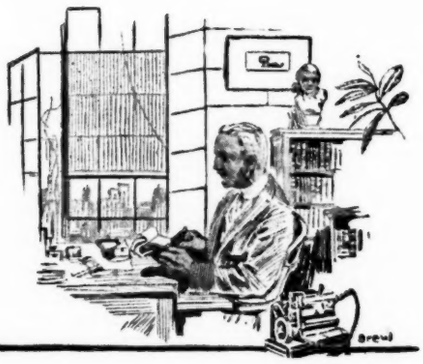
Mr. Easton, in the Dec. 6 issue, objects to a valve between the water column and the boiler, because it can be closed by anyone after breaking the seal. This objection can be overcome by using a chain, passing it through the yoke and around a spoke in the handwheel and padlocking the chain. The key of the lock should be kept by the man in charge of the plant. If it is necessary to shut the valve, this man should remain on hand during the time the valve is closed and after any work that is being done has been taken care of, the valve is locked opened, and the man in charge pockets the key so that the valve cannot be tampered with.

Where a number of valves are required, as in a large power plant, locks can be procured that take a master key. This arrangement is being used successfully by a number of plants.

HARRY A. BURDORF.
Cincinnati, Ohio.

To change a centigrade temperature into Fahrenheit multiply by 1.8 and add 32. For example, 20 deg. C. = $(20 \times 1.8) + 32 = 36 + 32 = 68$ deg. F. To change Fahrenheit to centigrade subtract 32 and divide by 1.8. Suppose, for example, the temperature is 210 degrees Fahrenheit, then the centigrade temperature = $(210 - 32) \div 1.8 = 178 \div 1.8 = 98.9$ deg. C.

QUESTIONS AND ANSWERS



Superheating Steam in Horizontal Return-Tubular Boiler

Why cannot superheating of steam be performed in a horizontal return-tubular boiler by having fire tubes in the steam space above the water line? E. F. D.

Superheating of steam in the presence of the water of the boiler can be performed only very imperfectly, as the superheat is rapidly absorbed by the water in generation of dry saturated steam of higher pressure. Besides, it would be impractical to employ fire tubes for the purpose, from the well-known fact that boiler tubes are quickly burned out unless they are covered by the water of the boiler.

High Velocity of Gases Through Water-Tube Boiler

It is generally conceded that increasing the velocity of the furnace gases through a water-tube boiler results in better transmission of heat by the tubes This, however, is not in accord with the opinion that, on account of the time element in making transfer of heat from one medium to another, the slower the velocity in the movement of one past the other the better on account of the greater the time for the transfer. Is the advantage of higher velocity due to more intimate contact from greater impinging effect of the gases against the tubes? M. R. P.

The higher velocity results in more complete transfer of heat of the gases as a whole from more thorough mixture and circulation of the gases over the tube surfaces, rather than the higher rate of transfer of heat to the limited areas of tube surfaces that receive impingement of the heated gases.

Use of Auxiliary Back-Pressure Relief Valve

Where steam from a high-pressure boiler is supplied to a heating system through a pressure-reducing valve and the system is also supplied with exhaust steam from an engine, is it necessary to have a back-pressure relief valve on the branch which connects the engine's exhaust with the heating system as well as another such valve on the main exhaust that discharges to the atmosphere? P. M.

The back-pressure relief valve on the main exhaust to the atmosphere will relieve the engine of back pressure that may be in excess of the pressure for which the valve is set, provided the live steam that is supplied through the reducing valve is not of higher pressure, and the heating apparatus receives all the steam offered to it at that pressure. Under these conditions none of the exhaust of the engine is contributed to the heating branch, and none of the boiler steam flows over to the engine exhaust to be relieved to the atmosphere. But when the steam received from the pressure-reducing valve becomes banked up to a higher pressure than the relief pressure for which the back-pressure valve on the engine exhaust pipe is set, the steam rejected by the heating apparatus would be discharged along with the engine exhaust through the back-pressure relief valve with more or less increase of back pressure on the engine, depending on the amount of the excess steam received from the boiler.

Under ordinary conditions the increase of engine back pressure would be small and could be obviated by having a back-pressure relief valve in the exhaust branch to the heating system in addition to the one in the main exhaust pipe, but there would be the same waste of live steam and no better utilization of the engine exhaust by the heating apparatus.

On the other hand, the difficulty of adjusting engine back pressure and reduced steam pressure to requirements of the heating system to prevent waste of live steam, would be increased, so that placing a back-pressure valve in the exhaust branch to the heating system would be of no benefit.

Friction of Shafting

What is the formula for computing the power lost by friction of shafting? F. R. B.

The power lost by friction of shafting that is in fair alignment running in babbitted bearings and based on frictional coefficients that have been established by careful tests, is given for each bearing by the formulas,

(1) $P = \dfrac{W \times d \times r.p.m.}{1{,}800{,}000}$, or about $0.00{,}000{,}056 \times Wd \times r.p.m.$ for ordinary oiling and

(2) $P =$ about $0.00{,}000{,}034 \times Wd \times r.p.m.$ for continuous oiling.

In these formulas,

P = Number of horsepower absorbed by journal friction;

W = Resultant of weight of shafting and pulleys and stress of belts, in pounds;

d = Diameter of journal in inches;

$r.p.m.$ = Number of revolutions per minute.

General Formula for Excess Air

How is the percentage of excess air determined from the percentage of CO_2 in the flue gases? R. L. S.

Excess air is admitted in excess of the amount theoretically required to furnish enough oxygen for complete combustion of the fuel, according to its chemical composition, and no general formula can be constructed for determining the per cent of excess air in the flue gases without reference also to the CO and O_2 present. But assuming, as in the case of anthracite coals, that the air

supply is principally required for combustion of carbon, an approximation of percentage of excess air based on the percentage of CO_2 can be found by subtracting the observed percentage of CO_2 from 20.7, dividing the remainder by the observed percentage and multiplying by 100. Suppose, for instance, that the CO_2 were 8 per cent, then the approximate percentage of excess air passing through the fire would be $\frac{20.7 - 8}{8} \times 100$, or $\left(\frac{20.7}{8} - 1\right) \times 100 = 158.7$ per cent.

A more accurate method is to determine the percentage of excess air from the amount of CO_2 and oxygen in the flue gases. A simple alignment chart for the purpose is given on page 568 of October 11, 1921, issue of *Power*.

Breakage of Hoisting-Engine Main-Bearing Stud Bolts

We are troubled with frequent breakage of stud bolts for holding the caps of main bearings on our hoisting engine. The bearings appear to be a good fit and there is no knock. The stud bolts have been set up by different mechanics, but break about every two weeks. How can we overcome the trouble? R. L. M.

Breakage of the studs undoubtedly occurs from continual backward and forward movement of the bearing caps. Means should be taken to hold the caps rigidly to the bearings by use of the proper thickness of shims on each side of the journals to leave the proper running tightness of journal bearings, after the stud nuts have been set down as hard as proper without danger of twisting off the bolts or stripping the screw threads.

Cushioning Duplex Pump

How is the cushioning of a duplex steam pump obtained and regulated? W. N. R.

The steam cylinders are provided at each end with two sets of ports. Each outer port acts as the steam admission port and terminates at the end of the cylinder so as to guide the incoming steam into the clearance space behind the piston; and each inner port acts as an exhaust port and terminates nearer the middle of the cylinder. When the steam piston passes over the exhaust port, no more exhaust steam can escape and, without cushioning valves, whatever steam is thus entrapped in the cylinder is compressed and acts like a cushion in bringing the piston to rest. This compression may be excessive and, by means of hand-operated compression valves that connect the outer or steam ports of the cylinder with the inner or exhaust passages, the amount of cushioning can be reduced, by permitting more or less of the compressed exhaust to escape from the end of the cylinder through the steam passage into the exhaust passage.

Calculating Size of Wire for Induction-Motor Feeders

A load of 200 hp. of 440-volt three-phase induction motors is located 400 ft. from the source of power. If the average power factor is 0.75, what size conductors are required to transmit the power with a drop of 8 volts in the line, the conductor to be run open and located in the same plane 4 in. apart? The frequency of the system is 60 cycles. P. J.

An allowable voltage drop in this circuit of 8 volts is very conservative, therefore, we will allow this to be the resistance volts drop, which will make the actual drop somewhat higher. The average efficiency of the motors may be assumed to be 0.85. Then, with all the motors on the circuit operating at full load, the current per conductor is

$$I = \frac{HP. \times 746}{E \times P.F. \times Eff. \times 1{,}732} = \frac{200 \times 746}{440 \times 0.75 \times 0.85 \times 1.732} = 307 \text{ amperes}$$

In a three-phase three-wire circuit with the conductors symmetrically arranged and carrying a balanced load, the inductive effect is the same in each wire and the calculations for volts drop may be made exactly as they would be for a single-phase circuit carrying one-half the load.

One-half the load in this case is 100 hp. and the current is

$$I = \frac{HP. \times 746}{E \times P.F. \times Eff.} = \frac{100 \times 746}{440 \times 0.75 \times 0.85} = 266 \text{ amperes}$$

For the approximate size of wire the single-phase formula may be used. Then

$$\text{Circ. mils} = \frac{22IL}{E_d} = \frac{22 \times 266 \times 400}{8} = 292{,}600 \text{ circular mils},$$

where I equals the current in amperes, L the length of line one way, and E_d the allowable resistance volts drop. The nearest standard-size wire to that obtained by the formula is 300,000 circ.mils. For open work the National Board of Fire Underwriters will allow 400 amperes on this size wire, therefore, if it will meet the requirements and may be used for the motor feeder circuit with 307 amperes.

The resistance volts drop with the 300,000-circ. mil conductor is

$$E_d = \frac{22 \times I \times L}{\text{Circ. mils}} = \frac{22 \times 266 \times 400}{300{,}000} = 7.8 \text{ volts}.$$

Since the conductors are not symmetrically spaced, the average distance between them will be taken and used as if they were symmetrically spaced on this distance. Two pairs of the conductors are 4 in. apart and the outside pair is 8 in., giving an average of $(4 + 4 + 8) \div 3 = 5.5$ in. approximately, on, say, 6 in.

The reactance — volts drop per ampere for 1,000 ft. of 300,000-circ.mil conductors spaced on 6-in. centers on a 60-cycle circuit is 0.0765, as obtained from a table given in the "American Electrician's Handbook." For 800 ft. this value would be $\frac{0.0765 \times 800}{1{,}000} = 0.0612$ volt. Then the total reactance drop E_r is equal to total current times reactance drop per ampere, or $E_r = 266 \times 0.0612 = 16.3$ volts. The resultant drop in the line is equal to $\sqrt{E_d^2 + E_r^2} = \sqrt{7.8^2 + 16.3^2} = 18$ volts. The actual drop will be somewhat less than this value (18 volts). Even if the drop was 18 volts, the regulation would be about 4 per cent, and this is exceptionally good. If the generator voltage is held around 450, then the motor volts will be close to 440.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Maintaining Efficiency in Industrial Power Plants

COMPLICATED plant layouts, too many instruments, disinterestedness of the industrial manager and lack of knowledge on the part of the engineering staff, were given as the causes of isolated power-plant failures at a joint meeting of the New York section of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers. Two papers were presented: "Power in Industrial Plants," by John S. Griggs, Jr., consulting engineer, New York City; and "Steam-Electric Power for the Industries," by Harold Goodwin, Jr., consulting engineer, Philadelphia, Pa. An abstract of Mr. Grigg's paper is published elsewhere in this issue.

Mr. Goodwin's paper was based on the Superpower Report, especially the material used in the article, "Analysis of Industrial Power," by the author in the Oct. 18, 1921, issue of *Power*. There has been considerable agitation on the amount of coal that could be saved in inefficient small plants; however, the Superpower Report shows that if all the coal used in plants of 500-hp. capacity and less were saved, it would be comparatively small. Where the great saving must be made, is in the medium-sized and large industrial power plants, since it is these that represent the great bulk of power generated by isolated plants. The largest consumers of coal in the Superpower Zone are the coal mines. At the anthracite mines about 10 per cent of all the coal mined is burned, while the bituminous mines burn about 2½ per cent of the coal mined. Mr. Goodwin illustrated his paper with a number of lantern slides, among which was the table given herewith. This table shows industrial power grouped according to percentage of prime movers (except waterwheels) that might have been replaced by superpower in 1920. This table shows that in such industries as sugar and lumber all the power should be generated in isolated plants, where in mining and some other industries it will be profitable to purchase all the power. Between these two limits there is a wide range of purchased and generated power combinations recommended for the various industries. For the whole Superpower Zone, according to this table, 70 per cent of the aggregate power might have been replaced by purchased power. The numbers appearing on the left of the table correspond to those used in Table I in the Oct. 18, 1921, issue of *Power*, page 585.

Discussion on the Paper

In the discussion attention was called to results obtained with a group of 24 water-pumping stations located in different parts of this country, by organizing an efficiency force of three men. Two of these men have set up a complete cycle of recording instruments from the coal pile to the water delivered, and the other man, an experienced operator, makes up reports of how best to maintain efficiency. In one plant in the West in two months 10 per cent improvement was made in efficiency by the plant's operating force. In another plant that was remodeled, the coal bill was cut in half, due to having installed recording instruments that showed a complete cycle of operation. The three men, working for about a year on 24 properties, have made an average improvement in efficiency of 7 per cent.

Low power factors were also blamed for some of the ills of the industrial power plant. One case was cited where, owing to over-motoring, a power factor of less than 50 per cent was obtained. After rearranging the motor equipment in the plant, the power factor was increased to 92 per cent. The opinion was expressed that it is better practice to install motors of the proper size for the load and if at some future date increased power is required, to purchase new motors and dispose of the old ones. This was considered cheaper than installing the larger motors at first and being subjected to the bad results of low power factor due to over-motoring.

As an illustration of what could be done to improve the efficiency in sugar plants, attention was called to one case where fuel representing about 2 per cent of the weight of sugar had to be purchased in addition to the available bagasse, to supply the necessary process steam. After a careful analysis of the steam requirements it was decided that the most economical arrangement was to utilize all the exhaust steam from the turbo-generators, up to the power requirements of the plant; and beyond these requirements to use high-pressure steam. This system has resulted in economies that made it possible to produce the process steam by burning the bagasse only, no outside fuel having to be purchased.

INDUSTRIAL POWER, GROUPED ACCORDING TO PERCENTAGE OF PRIME MOVERS (EXCEPT WATER WHEELS) THAT MIGHT HAVE BEEN REPLACED BY SUPERPOWER.

	Industry Subgroup	Aggregate Hp.	Prime-Mover Hp.	Purchased Hp.	Prime Movers Replaced by Superpower Per Cent	Prime Movers Replaced by Superpower Hp.
1d.	Sugar refining	35,041	35,041	0	0	0
3a.	Blast furnaces	183,833	183,395	438	0	0
4a.	Lumber	76,222	71,288	4,934	0	0
5a.	Leather, tanned, curried	87,929	58,485	39,444	17	10,000
2d.	All woolen goods	380,229	317,237	62,992	20	54,000
2f.	Dyeing and finishing	142,520	118,917	23,603	23	35,000
8d.	Petroleum refining	66,517	65,020	1,497	23	15,000
15	Laundries	55,087	44,371	10,716	23	10,000
9a.	Cement	162,066	114,886	47,180	25	29,000
2e.	Carpets and Rugs	31,999	25,704	6,295	29	7,000
2b.	Knit goods	88,439	53,402	36,037	37	17,000
3b.	Steel works, rolling mills	571,666	489,943	81,723	38	185,000
2i.	All other textiles	47,969	23,538	24,431	54	12,000
2h.	Clothing	83,914	26,597	57,317	60	15,000
8c.	Gas, manufactured	108,197	103,792	4,405	60	62,000
2g.	All other fabrics	104,078	81,169	22,909	65	40,000
8e	All other chemicals	289,867	184,965	104,902	65	125,000
7	Liquors and beverages	113,934	101,762	12,172	71	71,000
2c.	Silk goods	139,061	80,052	59,009	74	54,000
8a.	Coke	39,746	20,732	19,014	75	15,000
14c.	Electrical machinery	225,195	122,113	103,082	76	92,000
3c.	Locomotives, not by railroads	71,106	22,585	48,521	77	17,000
5b.	Leather finished products	90,152	45,976	44,176	80	35,000
1a.	Slaughtering	50,300	33,350	16,950	81	27,000
9d.	All glass products	13,046	5,822	7,224	83	4,800
14b.	Rubber goods	175,120	88,067	87,053	83	70,000
2a.	Cotton goods	895,513	713,879	181,634	87	500,000
14f.	All other miscellaneous	270,030	162,131	107,899	87	136,000
4b.	Furniture and other wood	204,311	135,117	69,194	88	112,000
10a.	Metals, non-ferrous	297,209	195,826	101,383	90	175,000
1e.	All other food products	179,351	99,549	79,802	91	88,500
9c.	All clay products	93,602	67,292	26,310	91	59,000
1c.	Bread and bakery products	72,377	18,556	43,821	92	17,000
6b.	Manufactures of paper	55,887	32,043	23,844	94	28,700
14a.	Miscellaneous metal work	60,783	33,755	27,028	94	30,000
10b.	Metal products, non-ferrous	108,040	49,948	58,092	95	45,000
12a.	Automobiles	58,307	16,094	42,213	95	15,000
14d.	Ice, manufactured	111,318	82,566	28,752	96	79,000
3d.	All other iron and steel products	919,150	479,581	439,569	97	442,000
9b.	All other stone prod.	76,304	41,351	34,953	97	40,000
1b.	Flour and grist mill products	58,115	45,588	12,527	99	17,000
6c.	Printing and publishing	168,456	31,710	136,746	100	31,600
8b.	Explosives	19,522	16,049	3,473	100	15,300
11	Tobacco manufactures	15,334	8,733	6,561	100	8,500
12b.	Cars, not by railroads	22,628	5,398	17,230	100	5,400
12c.	All other vehicles	14,445	6,730	7,715	100	5,600
13a.	Steam-railroad repair shops	100,344	67,744	32,600	100	67,000
13b.	Electric-railroad repair shops	19,562	805	18,757	100	800
14e.	Shipbuilding	229,078	57,478	171,600	100	57,000
16a.	Anthracite mines	899,726	782,223	117,503	100	782,000
16b.	All other mines and quarries	111,031	75,050	35,981	100	73,000
17	Government manufacturing inst.	102,729	77,534	25,195	100	76,600
	Grand total	9,069,471	6,247,002	2,822,469	70	4,008,200

The desirability of making the management of industries realize the importance of combustion engineering was emphasized. It was pointed out that too much attention had been centered on the high efficiency of individual equipment and not enough on the efficiency of an intelligent combination of all the equipment in the plant.

Reference was made to installations where the results of the low-pressure turbine had been disappointing. In many cases the results obtained in theory are beyond the reach of every-day practice. Where the bulk of the cost is the manufacturing end, the power end is liable to be neglected.

The cost of making records attracted considerable attention. The opinion was expressed that in plants of less than 200-hp. capacity the cost of keeping complete records amounts to more than the possible saving. It was considered that much better results would be accomplished if these plants were designed as simply as possible. A plant of two boilers, one engine and one of everything else was suggested. By operating only one boiler at a time and weighing the coal burned and measuring the power output of the plant, the operator would be in a position to maintain a higher efficiency in the small plant, than will all the complications that are found in some of the present small installations.

Stress was laid on the use of a minimum number of instruments to obtain an intelligent record of operation. These instruments should be easily read and easily maintained.

A suggestion was made to group the small industrial plants and have each group employ a technical staff to keep them operating at high efficiency. The objection raised to this scheme was the difficulty of doing anything in any plant on account of the opposition of those who are in the plants.

One of the serious causes of inefficiency in many plants is that they have just grown and are made up of a lot of small units not suited to the service. This makes the plant difficult to operate and maintain and makes it costly to keep records of operation. In one plant having 75 boilers, a CO_2 content in the flue gases was found as low as 4 per cent. It is evident that with such a large number of small boilers it would be expensive to obtain a complete record of boiler operation.

Ford Offer Goes to Congress with Secretary Weeks' Report

Power requirements for commercial purposes, as well as for various needs of the Government, justify the completion of the Wilson Dam at Muscle Shoals. This is the conclusion of the Secretary of War as contained in his letter transmitting Henry Ford's Muscle Shoals offer to Congress. Secretary Weeks made no recommendation in regard to the Ford offer, but he emphasized the need for the completion of the Wilson Dam by the Government itself if the Ford offer should not be accepted.

In meeting the criticism that delay is resulting in heavy maintenance costs at Muscle Shoals, Secretary Weeks pointed out that the $10,000 per month being received in rental for the steam plant, plus the kilowatt-hour charge, brings in sufficient funds to meet costs of maintaining the project in standby condition.

In his letter Secretary Weeks analyzed the Ford offer in great detail and showed that the proposal, as recently modified, would mean many millions more to the Government if accepted. He emphasized the need, however, of some assurance that the contracts made by the company Mr. Ford proposes to form will be carried out. Secretary Weeks suggested that there should be no departure from the provisions of the Water Power Act, particularly in the matter of limiting the contract to a term of fifty years. He summarized the modified Ford proposition in the following words:

In brief, Mr. Ford offers to undertake the completion of Dam No. 2 and the construction of Dam No. 3 according to the Government's plans, for which he shall be reimbursed the actual cost, and to lease the dams and power plants at an annual rental equivalent to 4 per cent of the cost to the Government of completing Dam No. 2 and constructing Dam No. 3 (exclusive of the cost of acquiring lands and flowage rights necessary for Dam No. 3). The rentals of 4 per cent are to commence, respectively, in six years after Dam No. 2 has been completed to the point where equipment for 100,000 hp. is installed and ready for service, and three years after the equipment to develop 80,000 hp. is installed and ready for service at Dam No. 3. In the meantime, during the six-year and three-year periods, respectively, he offers to pay, upon Dam No. 2 an annual rental of $200,000, and on Dam No. 3, $160,000.

His offer places upon the United States the responsibility for repair and maintenance of the two dams other than the power houses, which power houses and electrical equipment he agrees to maintain at his own expense in efficient operating condition. As compensation to the United States for the repair and upkeep of Dam No. 2 and locks he offers to pay the sum of $35,000 annually, and of Dam No. 3 and lock the sum of $20,000 annually. He also agrees to furnish electricity for operating the locks at each of these dams without charge to the Government, and in addition he agrees to pay the sum of $23,373 semi-annually for the purpose of building up a sinking fund to return to the United States at the end of the lease period, a sum of money which he estimates if invested at 4 per cent will be approximately $49,000,000.

As a condition of this offer he asks that the United States sell to him Nitrate Plants Nos. 1 and 2, the Waco Quarry, and the Gorgas-Warrior Steam Plant, with all appurtenances for the sum of $5,000,000, payable $1,000,000 down and the balance in annual installments of $1,000,000 each with 5 per cent interest on deferred payments. As a further consideration to the Government he agrees to operate Nitrate Plant No. 2 at the approximate present annual capacity of its machinery and equipment in the production of nitrogen and other fertilizer compounds throughout the lease period, and to maintain it in its present state of readiness, or its equivalent, for immediate operation in the manufacture of materials necessary in time of war for the production of explosives. He further agrees that the fertilizer produced at Nitrate Plant No. 2 shall not be sold at a profit in excess of 8 per cent of the actual annual cost of production thereof, and to turn over to the United States, Nitrate Plant No. 2 whenever it shall be required for the national defense. He likewise asks for a preference in opportunity to purchase or lease the property at the end of the lease period and for the right for a period not stated, to be supplied with electric power at reasonable rates in an amount equal to his average consumption during the previous ten years, in case the plant is operated and his company does not purchase or lease it. He also states that his proposal must be accepted as a whole and not in part.

An analysis of Ford's proposal by the Ordnance Department, submitted to Congress as an appendix to the Weeks letter, contains the following paragraphs:

The Ford offer, from the standpoint of the Ordnance Department, has the very important advantage of assisting materially in the development of nitrogen preparedness and has the disadvantage of conflicting with contractural obligations with the American Cyanamid Company and the Alabama Power Company, and of making a net return to the Government of less than $5,000,000 for properties which have an estimated salvage value of some $16,000,000.

The difference, $11,000,000, appears therefore to be the price which the United States is paying for nitrogen preparedness. If the plant is diverted to any purposes which do not include nitrogen fixation, this asset is lost to the Government.

A few days before Mr. Ford's proposition was put before Congress, the National Agricultural Conference went on record as favoring the offer by passing a resolution reading as follows:

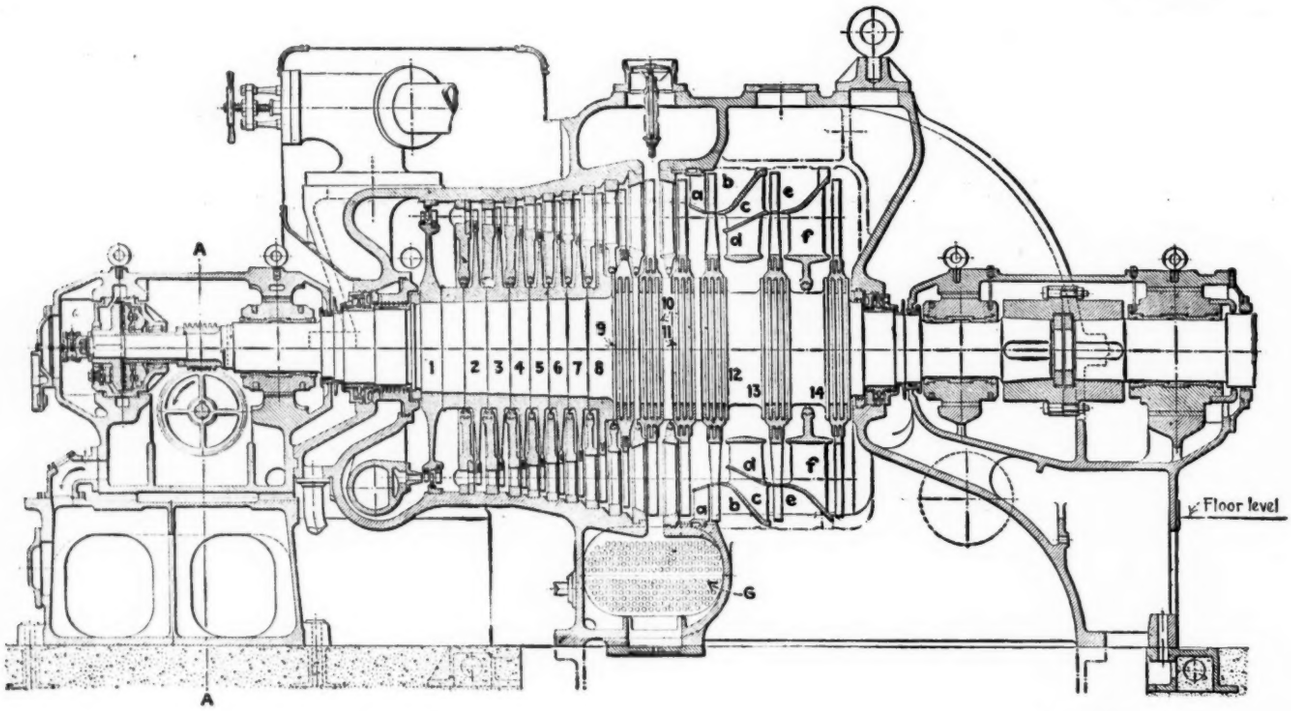
To accomplish results without any further delay whatever, we urge the Secretary of War to recommend, and the Congress to accept, Henry Ford's proposal to take over the hydro-electric power and air-nitrate plant at Muscle Shoals, under a guarantee to operate same for one hundred years at its present capacity of approximately 100,000 tons of ammonium nitrate per annum, opening the Tennessee River to navigation, cheapening the production of fertilizer, metals and other commodities, and assuring the United States nitrogen independence in peace or war.

In opposition to this resolution, Charles H. MacDowell, president of the National Fertilizer Association, spoke at considerable length, explaining the attitude of the fertilizer-manufacturing interests. He objected to statements being made in the newspapers that these interests are maintaining a lobby against the Ford offer, stating that the fertilizer industry is openly opposed to some of the features of the proposal, and is fighting them in an open and aboveboard way.

British Turbine Is Unique in Many Respects

THE Dec. 30, 1921, issue of the British journal, *Engineering*, contains an extensive article describing a 12,500-kw. turbo-generator recently installed in the Liverpool (England) Corporation Electricity Works. This unit, which was designed and constructed by the Metropolitan-Vickers Electrical Co., Ltd., of Manchester, England, embodies some notable departures from previous types of impulse steam turbines. The following description is based on information contained in the aforementioned article, and the figure has been reproduced from the same source.

This unit is designed to develop 12,500 kw. at full load and to take an overload of 25 per cent, while the generator design permits this overload to be carried for two hours at 80 per cent power factor. The turbine is 17 ft. long, 13 ft. wide, 6 ft. 9 in. high, and weighs 50 tons. The generator, on the other hand, is 21 ft. long, 12 ft. wide, 6 ft. 6 in. high and weighs 75 tons. It is claimed that the rotary speed of 3,000 r.p.m. exceeds that of any previous turbo-generator of equal capacity.



CROSS-SECTION OF TURBINE, SHOWING MULTI-STAGE EXHAUST AND BLEEDER HEATER

Steam is supplied at 185 lb. gage and 150 deg. superheat. The vacuum is only 27½ in., due to the fact that condensing water is limited in quantity and is supplied by cooling towers.

The figure is a longitudinal section through the turbine and shows clearly some of the unique features of the design. The turbine consists of one velocity-compounded stage followed by ten Ratteau stages and then by a multi-stage exhaust, which constitutes the most striking of the innovations embodied in the design. The mean diameter of the low-pressure end is 42 in., the same as that of the high-pressure end. With the usual type of design, this would provide a leaving area of about 16 sq.ft., but this is increased to 23 sq.ft. by means of the multi-stage exhaust, so that the "throw-away" loss to the condenser is as small as if the exhaust end of the turbine were on the double-flow principle.

Referring to the figure, it will be seen that there is no diaphragm immediately after wheel 11, but merely a ring of guide vanes *a* projecting inward about 5⅜ in. Therefore, some of the steam leaving wheel 11 enters *a* and is expanded down to the condenser pressure before reaching the outer section *b* of wheel 12. Another portion of the steam from wheel 11 passes directly to the inner ring of wheel 12, which is provided with reaction blades that produce a slight drop in pressure but maintain the velocity. The steam discharged from the inner blades of wheel 12 enters the diaphragm vanes *c* or *d* according to what part of the blade it comes from. The vanes are designed to act as expanding nozzles, giving velocity to the steam before it impinges on the impulse blading that constitutes the outer portion of the wheel 13, from which it escapes to the exhaust. The rest of the steam proceeds through *d* and the inner blades of the wheel 13. After leaving 13, it passes through the expanding guide vanes *f* and, after acting on the impulse blades of the wheel 14, passes to the condenser.

To sum up, the steam flow in the multi-stage exhaust is divided into three currents. Of these, the outermost is expanded at once down to the condenser pressure and drives wheel 12. The middle current proceeds with only a small change of pressure to a second set of guide vanes and drives wheel 13, while the innermost current similarly drives wheel 14.

The small heater shown at *G* is supplied with steam bled from the turbine after passing wheel 10, where it has a pressure corresponding to a 19-in. vacuum. This is used to heat the condensate from 109 deg. F. to 146 deg. F. Further heating of the feedwater is effected by a subsidiary heater supplied with steam from gland leakage.

The turbine rotor embodies some unusual mechanical features which make it possible to build turbines to give large outputs at the rated speed while insuring that the critical speed is well above the running speed. At the exhaust end, for example, the wheels are but little larger than the rotor shaft, and they are accordingly constructed and secured in a novel manner. They are in fact made in halves and secured against contrifugal force by meshing collars turned inside of the wheels with similar collars on the shaft and riveting the whole together. Special machinery has been invented for the purpose of drilling the necessary holes for the rivets.

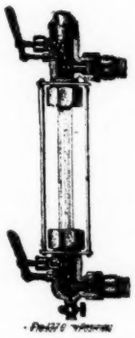
Condensed-Clipping Index of Equipment

Patented Aug. 20, 1918

Valve, Mattingly Automatic

Mattingly Automatic Valve Co., 201 Chouteau Trust Bldg., St. Louis, Mo.

"Power," 1922

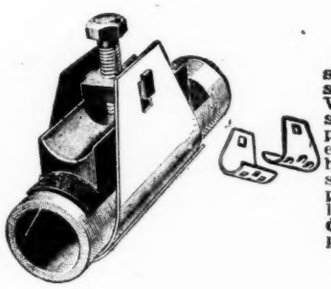


This valve is designed for use on steam boilers, ammonia and steam pipes, hose lines, etc. A glance at the lever shows when the valve is open or closed. It consists of a main valve, auxiliary valve and operating lever. The main and auxiliary valves travel in opposite directions and can never both be seated at the same time. When the lever pulls outward, the main valve is moved from its seat and the auxiliary valve is seated. The pressure exerted against the auxiliary valve pulls it to its seat and holds the main valve open. The valve will remain in this position until it is closed by hand or until the water glass or other connections become broken, in which case the pressure is released from the auxiliary valve and the main valve is forced to its seat.

Clamp, Blair "Kwikstop" Repair

Blair Products Co., 260 W. 29th St., New York City.

"Power," 1922

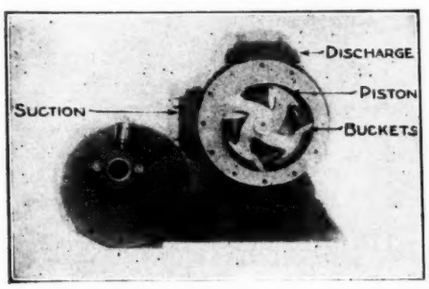


Consists of a two-piece steel shoe that hooks together, a steel shoe and a cast plate. When used, the steel shoe is slipped over the leak in the pipe and catches the hooked ends of the cast yoke in the holes in each end of the steel shoe. The gasket and the cast plate are then placed over the leak and the bolt screwed down in the center of the cast plate.

Pump, Blackmer Rotary

Blackmer Rotary Pump Co., Petoskey, Mich.

"Power," Dec. 13, 1921

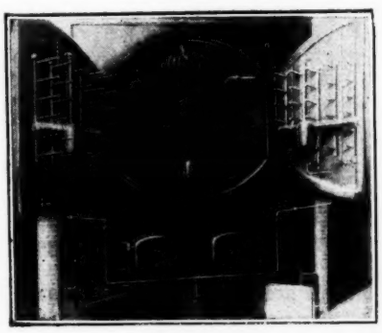


This pump consists of a cylinder, revolving piston and four buckets. The buckets drop into an extension chamber and pass to the right, and drawing liquid in at the suction push it out of the discharge at the top. As the piston revolves with the shaft, centrifugal force and gravity cause the buckets to be held against the cylinder, and air being exhausted from the suction line the liquid comes in and fills the extension chamber of the pump and is forced out of the discharge.

Cleaner, American Flue

American Flue Cleaner Co., 1826-28 East Willard Street, Philadelphia, Pa.

"Power," Nov. 8, 1921

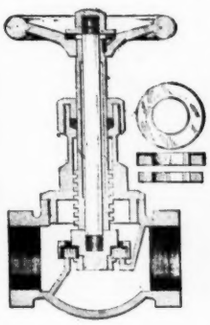


This flue cleaner is attached to the smoke-chamber doors of the boiler and swings outwardly with them when it is necessary to work on the boiler tubes, after breaking a connection. Each row of tubes is handled independently, having a valve that is part of the cleaner and that is made fast to the header. As each tube has a steam jet, the work of blowing the soot is continuous and all the tubes are blown at the same time. Automatic drip valves are provided, and the steam pressure from the separator holds them shut.

Valve, McCracken Improved

George B. McCracken, 55 Mountain St., Willimantic, Conn.

"Power," Nov. 22, 1921

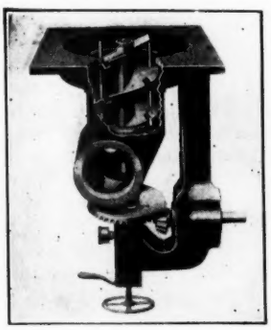


In this valve the disc holder is carried by a tube to and from the seat to open and close the valve. A spindle is screwed into the disc holder and is held aginst the end of the tube by a lock spring and nut. The stuffing nut and gland is provided with ratchet teeth on the bottom end which slides over the packing when the valve is being tightened, but loosens the packing at the same time so that it does not have to be as tight as it otherwise would. On reversing the nut for renewing the packing, the old material is loosened and easily removed. The disc holder is constructed to hold any form of disc, fibre or solid.

Feeder, Fuller S-H Pulverized Coal

Fuller-Lehigh Co., Fullerton, Pa.

"Power," Nov. 20, 1921



A pulverized coal feeding apparatus, designed to give a regular and uniform rate of flow, is adjustable to meet the variable fuel requirements of the furnace through a wide operating range. Two spiral propeller blades and agitator bars rotate with the shaft, which is driven by a gear and pinion. The agitator bars loosen the coal in the bin overhead, and the double-flight spiral revolves in a direction tending to raise the coal, thereby keeping it in an agitated flocculent state.

Conveyor, Steel Belt

Sandvik Steel Works American Agency, Tribune Bldg., New York City.

"Power," Dec. 27, 1921

This belt is made from Swedish charcoal steel, cold-rolled, hardened and tempered, and has a tensile strength of 177,500 lb. per square inch. It is cold-rolled in one piece in lengths up to 300 ft. The working stress of the belt when it passes over a standard-size pulley is 28,000 to 30,000 lb. per square inch. The joints are riveted.

Tachometer, Jones Centrifugal

Consolidated Instrument Co., 41 East 42nd St., New York City.

"Power," 1922

This new centrifugal tachometer, for use in connection with mechanical stokers, maintains a uniform scale over the entire dial. The actuating mechanism consists of a ball governor mounted on a revolving shaft. As the speed of the governor increases, the balls tend to rotate in a circle of greater diameter, which in turn has the effect of decreasing the length of the governor at right angles to the plane of rotation, or parallel to the center line of the revolving shaft. The movement is controlled by a special expansion spring and is transmitted through a pin actuating an adjustable arm. The corresponding movement is finally communicated to the pointer.

Clip, paste on 3 x 5-in. cards and file as desired

News in the Field of Power

N.A.S.E. Local Hears Lecture by Radiophone

The novelty of a lecture by wireless telephone was enjoyed recently by Trenton Association No. 4, National Association of Stationary Engineers. The lecture was transmitted from the radio station of F. S. Katzenback & Co., under the direction of J. L. Tower. Since this was the first lecture that had even been broadcasted for the benefit of the N. A. S. E., or probably of any engineering society, for that matter, it attracted considerable interest among engineers. It was heard by about 100 members in the lodge room, and doubtless by many others within a radius of 100 miles of Trenton who were able to "listen in."

President Mason, of the association, read the preamble to the constitution, and then introduced Robert T. Bowman, president of the Interstate Coal Corporation, of Scranton, through whose co-operation the speaker had been secured. Mr. Bowman told of the recent formation of the corporation by himself and his brother, Otis Bowman, and introduced the speaker, W. B. Calkins, a consulting fuel engineer, of Boston, who has been associated with the United States Fuel Administration and with the Tidewater Coal Exchange.

Mr. Calkins delivered a short lecture, which consisted mainly of advice regarding the purchasing, handling and sampling of coal for power-plant use. A few musical selections completed the wireless program.

It is reported that the educational committee of the association is planning similar wireless telephone lectures in the future, and it is even thought that the time may come when news from national conventions will be broadcasted among the various local associations.

Experiment Station Offering Research Assistantships

The Engineering Experiment Station of the University of Illinois is looking for young men who have been graduated from approved American or foreign universities or technical schools and who would like to undertake graduate study in engineering, physics or applied chemistry. Under the full quota of assistantships, there are expected to be eleven vacancies. Those who are appointed will be paid $600 a year, will be exempt from all fees except for matriculation and diploma, and will be expected to devote only half of their time to the work. Appointments are made for two consecutive collegiate years, and lead to the degree of Master of Science if all requirements are met.

Examinations for the appointment are made by the executive staff of the station on the basis of character, scholastic attainment and promise of success in the line of study to be followed. Preference is given to those having had practical engineering experience. Appointments are made in the Spring and become effective on the first of the following September.

Applications or requests for information should be addressed to the Director of the Engineering Experiment Station, University of Illinois, Urbana, Ill.

Feiker Back with McGraw-Hill, Still on Government Work

F. M. Feiker, vice president of the McGraw-Hill Co., Inc., who was given leave of absence last May to join the United States Department of Commerce as a special administrative assistant of Secretary Hoover, has resigned from the Department and returned to his work with the company. He has not, however, entirely broken off relations with Secretary Hoover, having been appointed a special agent of the Bureau of Foreign and Domestic Commerce, to carry on, in a consulting capacity, somewhat the same work that he has been doing.

Mr. Feiker's work with the Government extended to the Bureau of Standards, the Bureau of the Census and other parts of the Department of Commerce. He served as editorial adviser on the board of editors and took an active part in the reorganization of the department under the direction of Mr. Hoover. Mr. Feiker drew some fifty or sixty experts from the business world to the Department of Commerce, and co-operated with Dr. Julius Klein, director of the Bureau of Foreign and Domestic Commerce, in enlarging the industrial and business contacts of the Bureau, establishing business relations with trade association committees and creating the so-called Commodity Divisions of the Bureau.

The College of Engineering of New York University has opened an evening division recently, which will be conducted not only evenings but also Saturday afternoons, and which will include courses in civil, mechanical, electrical, chemical and industrial engineering. Further information may be obtained from the director of the Evening Division, New York University, College of Engineering, University Heights, New York City.

An international congress of engineers at Philadelphia in 1926 is being planned in connection with the Sesqui-Centennial Exhibition. The Engineers' Club of Philadelphia is making preliminary arrangements and the final plans for the affair will be worked out by representatives of the various national engineering societies at an early date.

California Water-Power Licenses Granted

Among the nine licenses granted by the Federal Power Commission at its meeting on Jan. 4, were two for the important projects of the San Joaquin Light and Power Co., on the San Joaquin River, in Fresno County, California, and of the El Dorado Power Co., on the South Fork of the American River in El Dorado and adjoining counties in California.

The license granted the San Joaquin company runs for fifty years and covers a public-utility project of 45,000 installed horsepower. The El Dorado company proposes to enlarge four existing reservoirs and to build two more, together with a diversion dam, a power house and a transmission line connecting with the existing system of the Western States Gas and Electric Co. The project has an estimated capacity of 20,000 horsepower.

A recent application for a preliminary permit has been asked by the Pacific Power and Light Co., for the construction of a dam about 100 ft. high and a power house in the Deschutes River at Reclamation Site, Oregon, the estimated capacity of the project being 30,000 horsepower.

Another recent application is that of Messrs Dougherty, Hutton and McNear, for a 15,000-hp. project, comprising a reservoir and power house on Cascade Creek, Thomas Bay, near Petersburg, Alaska. The site is in the Tongass National Forest.

Society Affairs

Coming Conventions

American Institute of Electrical Engineers—Midwinter convention at New York City, Feb. 15-17. Secy., F. L. Hutchinson, 29 West 39th St., New York City.

American Society of Mechanical Engineers—Spring meeting at Atlanta, Ga., May 8-11. Secy., Calvin W. Rice, 29 West 39th St., New York City.

National Electric Light Association—Annual convention at Atlantic City, N. J., May 15-20. Headquarters, 29 West 39th St., New York City.

Fort Wayne Section, A. I. E. E., is to meet Feb. 16 to discuss "The History and Future of Niagara." Frank B. Taylor will be the speaker and will use lantern slides.

The Engineering Society of Buffalo will meet Feb. 14 in the Iroquois Hotel for an address by Ralph H. McKee, professor of chemical engineering at Columbia University, on "Gasoline from Oil Shale."

Baltimore Section, A.I.E.E., on Feb. 17 will be told **of "The Design and Construction of the Hell Gate Station of the**

United Electric Light and Power Co.," by H. W. Leitch, mechanical engineer with the company. A complete story on this plant is being prepared for early publication in *Power*.

Cincinnati Section, A.S.M.E., and the American Society for Steel Treating will hold a joint meeting at 8 p.m. Feb. 14, at which Prof. H. F. Moore, of the University of Illinois, will speak on "The Fatigue of Metals," which was the subject of his recent investigations at the University's Engineering Experiment Station.

Metropolitan Section, A.S.M.E. will hold a joint meeting with the Stevens Engineering Society, Feb. 15, at Hoboken, N. J. "Recent Boiler Developments" will be the subject of the discussion and of a paper by V. Z. Caracristi. The meeting will be conducted in the auditorium of Stevens Institute, where the Society's first meeting was held over 40 years ago.

Virginia Section, A.S.M.E., is to hold an important meeting Feb. 17-18 at Virginia Polytechnic Institute, in Blackburgh. Friday morning's subject will be "Distribution of Coal," and in the afternoon papers will be given on "Transportation of Coal," "Electrification of Railways," and "Combustion of Coal on a Riley Stoker." There will be a banquet at 7 and a "Student Night" meeting at 8 p.m. On Saturday trips will be taken to the Bluestone Junction power station and to the coal mines at Pocahontas, Va.

Trade Catalogs

Water Turbines — Pelton Water Wheel Co., Inc., 19th and Harrison Sts., San Francisco, Cal., and 90 West St., New York City. Bulletin No. 17, 48 pages, describing not only the so-called Pelton, or impulse, type of wheel, but also the reaction turbine made by the same company. Governors and similar devices are also treated, and useful tables and educational matter are included.

Superheaters — Whitlock Coil Pipe Co., Hartford, Conn. A short bulletin, No. 30, describing the Whitlock all-steel superheater and its operation and performance.

Strainers — Elliott Co., Pittsburgh, Penn. Bulletin A, 36 pages, describing twin and single strainers for protecting condenser pumps and for other uses where débris must be kept out of the water supply.

Deaëration Process — Elliott Co., Pittsburgh, Penn. Bulletin N-1, 20 pages, on the Elliott process of extracting air and other dissolved gases from water, as used in power and heating plants to prevent corrosion.

Powdered Fuel—Hardinge Co., 120 Broadway, New York City. Catalog No. 12, "Quigley Fuel Systems," 48 pages, discussing the advantages of powdered fuel and describing methods of pulverizing, transporting, storing and burning. Very little space is devoted to the pulverizer itself, more attention being given to the other apparatus required and to the layout of the system.

Worthington Instruction Book — Worthington Pump and Machinery Corp., 115 Broadway, New York City. A 72-page booklet of instructions on the erecting, operating and repairing of Worthington horizontal, centrifugal volute pumps. It should be highly valuable to anyone handling a Worthington pump, but it also contains a lot of data that should be useful to anyone concerned with pump problems. Interesting figures are given showing the maximum water temperature allowable for different suction lifts.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run bases, f.o.b. mines):

Coal	Market Quoting	Jan. 23, 1922	Jan. 30, 1922
Pool 1,	New York	$3.20	$2.75@3.00
Pocahontas,	Columbus	2.15	1.85@2.50
Clearfield,	Boston	1.95	1.65@2.25
Somerset,	Boston	1.80	1.75@2.00
Pittsburgh,	Pittsburgh	2.15	2.10@2.20
Kanawha,	Columbus	1.65	1.50@1.85
Hocking,	Columbus	1.90	1.75@2.00
Pittsburgh No. 8	Cleveland	1.90	1.85@2.10
Franklin, Ill.,	Chicago	2.35	2.25@2.50
Central, Ill.,	Chicago	2.35	2.25@2.50
Ind. 4th Vein,	Chicago	2.55	2.35@2.50
Standard,	St. Louis	1.95	1.90@2.10
West Ky.,	Louisville	1.80	1.60@2.25
Big Seam,	Birmingham	2.10	1.75@2.00
S. E. Ky.,	Louisville	1.55	1.50@1.65

New York—On Feb. 1, Port Arthur light oil 22@25 deg. Baumé 4½c. per gal. 30@35 deg., 5½c. per gal., f.o.b. Bayonne, N. J.

Chicago—Jan. 21, for 24@28 deg. Baumé, 80@85c. per bbl.; 32@36 deg., 2⅜@2⅝c. per gal. in tank cars f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh—On Jan. 31, f.o.b. refinery, Pennsylvania, 36@40 deg., 3¾@4c. Oklahoma 24@30 deg., 75@80c. per bbl.; gas oil, 32@34 deg., 2¾c. per gal.; 36@38 deg., 3c., 38@40 deg., 3¼c. per gal.

St. Louis—Jan. 28, prices f.o.b. cars, tank lots; 24@26 deg. Baumé, 75c. per bbl.; 26@28 deg., 80c.; 28@30 deg., 95c.; 32@34 deg., 2½c. per gal.

Philadelphia—On Jan. 30, 26@28 deg. Baumé, Oklahoma, 75@80c. per bbl.; 30@34 deg., Oklahoma (group 3) 2½@2⅝c. per gal.; 16@20 deg., Seaboard, $1.15@$1.25 per bbl.

Cincinnati—Jan. 31, for 26@30 deg. Baumé, 3¾c.; Diesel 32@34 deg., 4¼c. per gal.; distillate 38@42 deg., 5c. per gal.

Cleveland — Jan. 31, 26@30 deg. Baumé, 2⅝c. per gal.

New Plant Construction

PROPOSED WORK

Ala., Birmingham—H. B. Wheelock, Steiner Bldg., will receive bids late in February for a 3 story, 200 x 240 ft. high school on 24th and 7th Ave. for the Bd. Educ. About $750,000.

Ala., Tuskegee—Treasury Dept., J. A. Wetmore, Supervising Archt., Wash., D. C., will receive bids about March 15 for the construction of a United States Public Health Service Hospital here. About $1,500,000. Noted Dec. 20.

Cal., Fair Oaks—The Carmichael Irrigation Dist., L. C. Sears, Secy., will receive bids until Feb. 11 for furnishing and installing pumping machinery, equipment and electrical apparatus in the pumping station, including 1 pump, 12 in. and 1 250 hp. motor. About $10,500. A. Givan, 1029 Forum Bldg., Sacramento, Ch. Engr.

Cal., Fresno—The Mendota Irrigation Dist., A. Teilman, Secy., Box 1274, plans election to vote $600,000 bonds for the construction of a dam 30 ft. high, 350 ft. long on top, 250 ft. long on bottom, power canal, 3 miles long, 45 ft. wide, concrete headgate, 60 ft. wide, 10 ft. high; power plant, using turbine water wheels and electric generators, fall 65 ft. J. D. Galloway, First Natl. Bank Bldg., San Francisco, Engr.

Cal., Weimar—W. A. Russell, Secy. Hospital Central Committee, will receive bids until Feb. 9 for the installation of kitchen and service equipment and refrigerating plant in the new service bldg. of Weimar Joint Sanitarium, near here. W. H. Weeks, 369 Pine St., San Francisco, Archt.

Conn., Hartford—J. Cutler, 128 Oakland Terrace, will soon award the contract for a 2 story, 49 x 140 ft. theatre including a steam heating system on Park St. F. C. Walz, 407 Trumbull St., Archt.

Del., Wilmington — The Wilmington Sugar Refining Co., Du Pont Bldg., is having plans prepared for a 5 story, 125 x 150 ft. sugar refinery (1st unit). About $800,000. Total cost $1,500,000. W. J. Wayte, Grand Central Palace, New York City, Archt. and Engr.

Fla., Howey—W. J. Howey, c/o Fuquay & Gheen, Daytona, plans to build a 4 story hotel here. About $300,000. Architect not selected.

Fla., Tampa—The Exchange Natl. Bank, 601 Franklin St., is having plans prepared for a 10 story, 100 x 105 ft. bank and office building including a steam heating system on Franklin St. Stone & Webster, 147 Milk St., Boston, Mass., and 120 Bway., New York City, Engrs. Noted Aug. 23.

Ga., Rome—C. H. Nichols, 216 West 5th Ave., is in the market for a 10 to 20 ton raw water, motor driven ice machine complete.

Ia., Muscatine—The city plans election Feb. 10 to vote $350,000 for municipal electric light and power plant. Noted Dec. 27.

Ill., Chicago—The Atwell Printing & Binding Co., Sherman and Polk Sts., plans to build a 6 story, 170 x 177 ft. printing plant including a steam heating system on Prairie Ave. and 12th St. About $700,000. Architect not selected.

Ill., Chicago—Kurz Bros., 1388 North Branch St., is in the market for one 500 to 600 hp. open feed water heater.

Ill., Chicago—The Sherwin Williams Co., 116th and Stephensen Ave., M. Inglis, Purch. Agt., is in the market for one 100 hp. A. S. M. E. horizontal tubular boiler. 100 or 125 lb. steam pressure, must be acceptable under Chicago and Illinois codes.

Ill., Chicago—M. Tauber & Sons Corp., 2231 Wabansia Ave., is having plans prepared for a 1 story, 67 x 190 ft. ice plant and a 1 story, 85 x 109 ft. garage at 2231 North Wabansia St. Total cost about $75,000. A. Eppstein, 2001 West 39th St., Archt.

Ill., Chicago—The Wesley Memorial Hospital, 3449 South Dearborn St., has had plans prepared and soon receives bids for an 8 story nurses home including a steam heating system on Dearborn and 35th Sts. About $500,000. Holabird & Roche, 104 South Michigan Ave., Archts.

Ind., Crown Point—J. N. Coleman, Archt., 6257 St. Lawrence St., Chicago, Ill., will soon receive bids for a hospital including a 2 story, 50 x 50 ft. power plant for the Crown Point Hospital. Total cost about $800,000. Noted Jan. 31.

Ill., Decatur — The Illinois Form Mortgage & Bond Co., 136 South Water St., is having plans prepared for a 10 or 12 story, 100 x 140 ft. store and office building including a steam heating system. About $1,000,000. W. T. Hooper, 201 East Ontario St., Chicago, Archt.

Ind., Whiting—N. S. Spencer & Sons, Archts., 37 West Van Buren St., Chicago, Ill., will receive bids until Feb. 11 for a 3 story, 90 x 140 ft. high school and a 1 story, 70 x 90 ft. grade school including a steam heating system for the Bd. Educ. About $500,000. Noted Feb. 22.

Kan., Hamilton—The city, c/o J. S. Wilson, Mayor, will soon award the contract for an electric light system, 11 miles transmission line, also laying 4 and 6 in. water mains. About $100,000. F. E. Delvin, Eldorado, Engr. Noted Jan. 24.

Kan., Wichita—Whalen & Reiff, 601 Schweiter Bldg., is having plans prepared for a 10 story, 112½ x 140 ft. office building on Market and 1st Sts. About $900,000. U. G. Charles & Co., 601 Schweiter Bldg., Archts.

Ky., Lexington—The American Metallic Packing Co. is in the market for a modern ice machine 15 to 20 ton capacity.

Mass., Fall River—The city will receive bids until Feb. 14 for a 2 and 3 story, 121 x 327 ft. tuberculosis hospital on Hood St. About $700,000. E. M. Corbett, 70 Bedford St., Archt.

Mich., Detroit—The Bd. Educ., 1354 Broadway Ave., will soon award the contract for a 2 story, 62 x 214 and 40 x 46 ft. school including a steam heating plant, boilers and Plenum system of ventilation, on Martin and Brayden Aves. Malcolmson, Higginbotham & Palmer, 405 Moffat Bldg., Archts.

Minn., St. Paul—The West Side General Hospital Assn., c/o J. M. Baitinger, 690 East 7th St., plans to build a 3 or 4 story hospital including a steam heating system at 225 Prescott Ave. About $250,000. Architect not announced.

Miss., Collins—The town plans to remodel electric light and waterworks system, and will probably install oil engines, pumps, elevated tank and tower. Swanson-McGraw, Inc., 705 United Fruit Bldg., New Orleans, La., Engrs.

Mo., Columbia—The University of Missouri will receive bids until Feb. 24 for a power plant including smoke stock, tunnel boilers and stokers, traveling crane, steam and water mains, piping, etc. E. E. Brown, Bus. Mgr.

Mo., Hannibal—The Bd. of Public Improvements, F. S. Morris, City Hall, is having plans prepared for street lighting system and power plant. About $170,000. Arnold & Co., 105 South LaSalle St., Chicago, Ill., Engrs.

Mo., Kansas City—S. Rubin, c/o W. W. Alschlager, Archt., 65 East Huron St., Chicago, Ill., is having plans prepared for a 19 story, 100 x 140 ft. office building including a steam heating system on 11th St. About $2,500,000.

Mo., Moberly—The city, c/o J. E. Curry, Clk., is having plans prepared for a pumping station, filtration plant, dam and reservoir. About $350000. Fuller & Beard, 1917 Railway Exchange Bldg., St. Louis, Engrs.

Mo., St. Louis—The Langenberg Hat Co., 12th and St. Charles Sts., is in the market for a 10 or 20 hp. boiler, high pressure.

N. J., Asbury Park—The Bd. Educ., E. H. Hurley, Pres., has had plans prepared for a 3 story high school. About $400,000. E. F. Arend, 105 West 40th St., New York City, Archts. and Engrs.

Neb., Cowles—The city plans to build waterworks pumping station and 11 miles transmission line and distribution system. About $25,500. Grant, Fulton & Letton, 505 Banker Life Bldg., Lincoln, Engrs.

N. Y., New York—The Roosevelt Hospital, 59th St. and 9th Ave., is having sketches made for an 8 story, 50 x 100 ft. addition to hospital on 9th Ave. and 59th St. About $1,000,000. York & Sawyer, 50 East 41st St., Archts. and Engrs.

O., Cincinnati—The Comrs. of Hamilton County, Court House, will receive bids until Feb. 10 for a 3 story, 60 x 207 ft. insane asylum including a low pressure steam heating system on Paddock Rd. About $300,000. Elzner & Anderson, Citizens Bank Bldg., Archts.

O., Cincinnati—The Norton Broadway Mchy. Co., 236 Bway., is in the market for a 20 hp. A.C. 220 volt motor, about 1200 R.P.M.

O., Cleveland—K. V. Painter, c/o W. J. Van Aken, 6523 Euclid Ave., is having plans prepared for a 6 story, 80 x 210 ft. commercial and office building at 2537 Euclid Ave. About $500,000. Architect's name withheld.

O., Dayton—The Terminal Ice & Cold Storage Co. will soon award the contract for an 8 story, 135 x 150 ft. addition to refrigeration plant on Baker and Ludlow Sts. About $500,000. G. B. Bright Co., 103 Marquette Bldg., Detroit, Mich., Archts. Noted Jan. 3.

Okla., Carter—The city is having plans prepared for an electric light and distribution system. About $25,000. V. V. Long & Co., Colcord Bldg., Oklahoma City, Engrs.

Okla., Foss—The city plans a bond election latter part of February for improvements to electric light plant. About $35,000. H. G. Olmsted, 415 Oil Exchange Bldg., Oklahoma City, Engr.

Pa., Monessen—The Bd. Educ. will soon receive bids for a 2 story, 138 x 200 ft. junior high school on 6th and Knox Aves. About $300,000. J. M. Beal & Sons, Archts. Former bids rejected. Noted Mar. 9.

Pa., Norristown—The Y. M. C. A., c/o H. C. Green, Norristown, plans to build a 4 story, Y. M. C. A. building on 4th St. About $350,000. H. G. MacMurtrie, 1012 Walnut St., Phila., Archts.

Pa., Phila.—The city will soon receive bids for furnishing and installing pump at the Roxbury Pumping Station. About $25,000. C. E. Davis, City Hall, Engr.

Pa., Phila.—The Frankford Arsenal, office of Constructing Quartermaster, Administration Bldg., will receive bids until Feb. 8 for a power plant including the installation of equipment.

Pa., Phila.—A. M. Merchen, Land Title Bldg., is having plans prepared for a 17 story, 190 x 230 ft. hotel and stores building on 9th and Chestnut Sts. H. Trumbauer, Land Title Bldg., Archt.

Pa., Pottsville — The Philadelphia & Reading R.R., 12th and Market Sts., plans to build a 7 story station and office building. About $300,000. Private plans.

Tex., Galveston—The Bd. of Comrs. will receive bids at the office of J. D. Kelley, City Secy., City Hall, until Feb. 21 for furnishing and installing machinery and equipment at the Alto Loma Pumping station, for supplying 8,000,000 gal. of water per day.

Tex., Mexia—The city plans election to vote $800,000 bonds for municipal improvements to include electric lighting system, incinerator and jail, also plan to purchase present waterworks system and make extensive improvements including the installation of new equipment. D. L. Harp, Mayor, J. F. Klotz, City Engr.

Tex., San Antonio—The city has appointed H. Phelps, Hicks Bldg. and A. B. Ayres, Bedell Bldg., Archts., to select site and prepare plans for an auditorium. About $500,000. D. D. Harrigan, City Engr.

Wis., Madison—Dane County, c/o M. Sommers, 512 West Wilson St., is in the market for complete refrigeration machinery.

Wis., Milwaukee—The Phoenix Knitting Co., 208 Bway., is having plans prepared for a 6 story, 120 x 180 ft. dye works and finishing plant, including a high pressure steam heating system, on Milwaukee St. Cost between $300,00 0and $400,000. Lockwood Greene & Co., 38 South Dearborn St., Chicago, Ill., Archts. and Engrs.

Wis., Racine—I. Friedman, 507 Main St., is having preliminary plans prepared for a 7 and 8 story, 80 x 120 x 145 ft. hotel on Lake Ave., 5th St. and Monument Sq. Cost between $300,000 and $500,000. E. B. Furston Co., Robinson Bldg., Archts. and Engrs.

Wis., Sheboygan—The Amer. Hide & Leather Co., 1102 Wisconsin Ave., E. Schnellen, Mgr., is having preliminary plans prepared for a steam ash shute and conveyor system. About $25,000. Address E. A. Juul, 805 North 8th St., Engr. Noted Jan. 17.

Wis., Wausau—D. L. Plumer Hospital, McIndoe St., will receive bids about Feb. 15 for a 3 and 4 story hospital and nurses home. About $300,000. Berlin, Swern & Randall, 19 South LaSalle St., Chicago, Ill., Archts.

Ont., Bluevale—The council, J. Porter, is having plans prepared for an electric light and power distribution system. About $28,000. J. N. Wilson, 190 University Ave., Toronto, Engr.

Ont., Brantford—The Water Works Comm. plans for an electric pumping station, including the installation of 3 stage centrifugal pumps with electric motors. About $250,000. F. P. Adams, City Hall, City Engr.

Ont., Goderich—The council, Mayor Wigle, plans improvements to waterworks system including erection and equipment of new pump house. About $40,000. A. Kelly, Engr.

Ont., Ottawa—L. W. Paulins, Sparks St., plans to build a store. About $300,000. Architect not selected.

Ont., Peterboro—The city is having plans prepared for a pumping station; electric driven centrifugal pumps will probably be installed. About $200,000. R. H. Parsons, City Hall, City Engr.

Ont., Port Elgin—The Council, Mayor McLaren, plans electric light and power distribution system. About $35,000. Prices wanted on equipment.

Ont., Southampton—The council, D. MacAulay, plans to build electric light and power distribution system. About $30,000.

Que., Montreal—The Canadian Finance & Trading Corp., 211 McGill St., plans to build a 2 story ice arena on Atwater Ave. About $400,000.

CONTRACTS AWARDED

Cal., Riverbank—The Atchinson, Topeka & Santa Fe Ry., 605 Market St., San Francisco, has awarded the contract for an 84 x 134 ft. ice plant, here, to Hayes-Oser Co., Call Bldg., San Francisco.

D. C., Washington—The Bureau of Yards and Docks, Navy Dept., has awarded the contract for power plant equipment and installation in the Naval Experimental & Research Lavatories to Shevlin Engr. Co., 110 West 34th St., New York City, $79,200. Noted Nov. 29. Spec. 4497.

Kan., Independence—The Bd. Educ., C. S. Risdon, Supt., has awarded the contract for a 3 story, 181 x 235 ft. junior high school to the Bruister Constr. Co., Independence. About $400,000. A steam heating system will be installed. Noted Nov. 29.

Mass., Cambridge—The Cambridge Elec. Light Co., Blackstone St., has awarded the contract for a 2 story, 70 x 192 ft. switch station on Western Ave. to J. F. Griffen Co., 19 Milk St., Boston. About $200,000.

Mo., Kansas City—S. S. Joy, archt., 2001 West 39th St., Chicago, Ill., has awarded the contract for an 8 story, 150 x 300 ft. ice and cold storage plant to E. W. Sproul & Co., 39th and Robey Sts., Chicago, Ill. About $1,000,000. Owner's name withheld. Noted Jan. 17.

N. Y., Brooklyn—The American Tobacco Co., 54 Park Ave., has awarded the contract for a 7 story, 50 x 90 ft. factory on Sanford St. to the Turner Constr. Co., 244 Madison Ave., New York City.

N. Y., New York—The 29 West 64th St. Corp., c/o G. F. Pelham, Archt., 200 West 72nd St., will build an 11 story 83 x 110 ft. apartment at 29 East 64th St. About $850,000. Owner will build by day labor.

N. Y., New York—The Beth Israel Hospital, Livingston Pl., has awarded the contract for an addition to hospital to G. R. Davis, 30 East 42nd St. About $1,500,000.

N. Y., New York—The Cutting-Larson Co., 109 West 64th St., has awarded the contract for a 6 story, 100 x 120 ft. automobile service building on 66th St., between 11th and 12th Aves. to Barney-Ahlers Constr. Co., 110 West 40th St. About $250,000.

N. Y., New York—The Knickerbocker Ice Co., 45 East 42nd St., has awarded the contract for a 7 story, 70 x 90 ft. ice plant on Elizabeth St. to the Turner Constr. Co., 244 Madison Ave.

N. Y., New York—The Treasury Dept., J. A. Wetmore, Supervising Archt., has awarded the contract for mechanical equipment in the Public Health Service Hospital here, to J. McMillan, 151 East 45th St., $49,387.

O., Cleveland—The city has awarded the contract for furnishing four water tube boilers for the Division of Water to Babcock & Wilcox, Guardian Bldg., $76,519; stokers to Sanford Riley Stoker Co., Swetland Bldg., $42,490. Noted Dec. 20.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

PRICES of magnesite and silica brick considerably higher; chrome brick and chrome cement slightly reduced. Leather belting discounts about 5 points lower than last month. Portland cement quoted at $2.20@$2.30 as against $2.30 per bbl., delivered in New York. Steel shapes quoted in New York warehouses at $2.63 as compared with $2.78 per 100 lb. one month ago. Discounts increased on steel and tinned rivets. Cold finished steel down 10c. in New York; 15c. in Chicago and 25c. per 100 lb. in Cleveland. Babbitt metal down in Cleveland and slightly higher in New York. Cotton waste 1c. per lb. higher in Chicago. Linseed oil quoted at 77c. as against 72c. in New York; advanced to 80c. from 76c. in Cleveland and at 80c. as compared with 74c. per gal. (5 bbl. lots) on Jan. 10 in Chicago.

POWER-PLANT SUPPLIES

HOSE—

	Fire	50-Ft. Lengths
Underwriters' 2½-in.		56c. per ft.
Common, 2½-in.		80 per ft. list less 50–5%

	Air	
	First Grade	Second Grade
¾-in. per ft.	$0.38	$0.22½

Steam—Discounts from List

First grade....40–10% Second grade...50–5% Third grade....50–10–5%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 60–10% Best grade..... 50–10%

LEATHER BELTING—Present discounts from list in fair quantities (½ doz rolls):

Light Grade	Medium Grade	Heavy Grade
50%	40–5%	35%

RAWHIDE LACING { For cut, best grade, 50–10%, 2nd grade, 60%
{ For laces in sides, best, 41c. per sq.ft.; 2nd, 39c.
{ Semi-tanned: cut, 50%; sides, 43c. per sq.ft.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam, ½ in.	$0.90
Asbestos for high-pressure steam, ½ in.	1.80
Duck and rubber for piston packing	.90
Flax, regular	1.10
Flax, waterproofed	1.70
Compressed asbestos sheet	.90
Wire insertion asbestos sheet	1.30
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.40
Asbestos wick, ½- and 1-lb. balls	.70

PIPE AND BOILER COVERING—Discounts are as follows:

85% magnesia high pressure		50% off
For low-pressure heating and return lines	4-ply	60% off
	3-ply	62½% off
	2-ply	64% off

PORTLAND CEMENT—New York, $2.20@2.30 without bags, in cargo lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $2.63 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York Current	Cleveland	Chicago
White	7.50@10.00	12.00	13.00
Colored mixed	5.50@ 9.00	9.00	11.00

WIPING CLOTHS—Jobbers' price per 1,000 is as follows:

	13½ x 13¼	13½ x 20½
Cleveland	$50.00	$55.00
Chicago	55.00	65.00

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$0.79	$0.80	$0.80

WHITE AND RED LEAD—Base price per pound:

	Red				White			
	Current		1 Year Ago		Current		1 Yr. Ago	
	Dry	In Oil	Dry	In Oil	Dry and In Oil		Dry and In Oil	
100-lb. keg	12.25	13.75	15.50	17.00	12.25		15.50	
25- and 50-lb. keg	12.50	14.00	15.75	17.25	12.50		15.75	
12½-lb. keg	12.75	14.25	16.00	17.50	12.75		16.00	
5-lb. cans	15.25	16.75	18.50	20.00	15.25		18.50	
1-lb. cans	17.25	18.75	20.50	22.00	17.25		20.50	

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅞ and smaller	60–5%	60–10–10%	65–5%
Tinned	60–5%	60–10–10%	4½c. per lb. net

Structural rivets, ½, ⅝, ¾ in. diameter by 2 in. to 5 in. sell as follows per 100 lb.

New York.....$3.50 Chicago.....$3.43 Pittsburgh.....$2.25

Boiler rivets, same sizes:

New York.....$3.60 Chicago.....$3.53 Pittsburgh.....$2.35

REFRACTORIES—Prices in carlots:

Chrome brick, eastern shipping points	net ton	$35@40
Chrome cement, 40@45% Cr_2O_3	net ton	21@23
Chrome cement, 40@45% Cr_2O_3, in sacks	net ton	23.50@25.50
Magnesite brick: 9-in. straight	net ton	53@58
Magnesite brick: 9-in. arches, wedges and keys	net ton	58@64
Magnesite brick: Soaps and splits	per ton	74@81
Silica brick: Chicago district	per 1,000	40@42
Silica brick: Birmingham, Ala.	per 1,000	42@45
Silica brick: Mt. Union, Pa.	per 1,000	35@38
Chrome ore crude, 45@50%	net ton	16@18
Magnesite dead burn (Imported)	net ton	28@30
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per 1000	35@40
Clay brick, 1st quality, 9 in. shapes, Ohio	per 1000	35@40
Clay brick, 1st quality, 9 in. shapes, Kentucky	per 1000	35@40
Clay brick, 2nd quality, 9 in. shapes, Pennsylvania	per 1,000	30@35
Clay brick, 2nd quality, 9 in. shapes, Ohio	per 1,000	30@35
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per 1,000	30@35

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
Best grade	31.00	41.00	36.00
Commercial	16.00	13.50	9.00

COLD FINISHED STEEL—Warehouse prices are as follows:

	New York	Chicago	Cleveland
Round shafting or screw stock, per 100 lb. base	$3.45	$3.40	$3.25
Flats, square and hexagons, per 100 lb. base	3.95	3.90	3.75

BOILER SPECIALTIES—F. o. b. **New York** or **Jersey City**, discounts on list:

	Current
Copper ferrules	75%
Boiler flanges	60%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	50%
Pressed steel boiler lugs	10%
Pressed steel boiler hangers	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the latest Pittsburgh basing card:

BUTT WELD

Inches	Steel Black	Galv.	Inches	Iron Black	Galv.
1 to 3	71	58½	¼ to 1½	44½	29½

LAP WELD

2	64	51½	2	39½	25½
2½ to 6	68	55½	2½ to 4	42½	29½
7 to 8	65	51½	4½ to 6	42½	29½
9 and 12	64	50½	7 to 12	40½	27½

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1¼	69	57½	1 to 1½	44½	30½
2 to 3	70	58½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	62	50½	2	40½	27½
2½ to 4	66	54½	2½ to 4	43½	31½
4½ to 6	65	53½	4½ to 6	42½	30½
7 to 8	61	47½	7 to 8	35½	23½
9 to 12	55	41½	9 to 12	30½	18½

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$0.22
1¼	.....	.....	.21
1½	.....	.....	.1755
1¾	$0.2134	$0.2404	.1936
2	.1638	.2069	.1701
2¼	.1872	.2364	.1944
2½	.1950	.2768	.2280
2¾	.2216	.....	.2584
3	.2470	.3505	.2698
3¼	.2610	.4039	.2925
3½	.2784	.4308	.3120
4	.3538	.5475	.3965

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per lineal foot based on stock lengths. If cut to special lengths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

1½ in. to 2 in. diameter, 5c. per cut. 2½ in. diameter, 7c. per cut
2¼ in. diameter, 6c. per cut. 3 in. diameter, 9c. per cut
3½ in. to 4 in. diameter, 10c.

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$ 42.00 (net)	$138.00	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:

Less than coil lots	25%	15%
Coils to 1,000 ft.	35%	30%
1,000 ft. and over	40%	35%

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever-Ready:

	Each, Net
Less than 12	$0.40
12 to 50	.34
50 to 125 (bbl.)	.30½
125 (bbl.) or over	.29

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f. o. b. New York, with 10-day discount of 5 per cent.

Take 5 per cent from these prices.

Size, In.	Conduit Black 2,500 to 5,000 Lbs.	Conduit Galvanized 2,500 to 5,000 Lbs.	Elbows Black 2,500 to 5,000 Lbs.	Elbows Galvanized 2,500 to 5,000 Lbs.	Couplings Black 2,500 to 5,000 Lbs.	Couplings Galvanized 2,500 to 5,000 Lbs.
¼	$45.97	$50.25	$ 9.54	$10.40	$4.09	$4.51
⅜	58.28	64.28	12.59	13.81	5.87	6.43
½	83.87	92.18	17.61	19.49	7.53	8.67
¾	114.00	125.00	24.75	27.15	10.68	11.76
1	136.20	149.50	32.78	35.90	13.19	14.56
1¼	172.84	191.30	60.44	66.88	17.58	19.27
1½	288.00	316.15	98.83	108.80	25.10	27.60
2	377.00	414.00	265.22	291.50	37.90	41.60
2½	478.00	566.15	570.06	627.40	51.05	56.20
3	586.00	644.20	670.00	737.50	62.74	68.94

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.	
⅜	250	$0.05½	
½	250	.06	
⅝	250	.09	
¾	200	.12	1000 ft and over....71%
⅞	200	.15	Coils.....55%
1	150	.18	Less coils, 45%
1¼	100	.25	
1½	100	.33	
1¾	Odd lengths	.40	
2	Odd lengths	55	

CUT-OUTS—Following are net prices each in standard-package quantities:

Take 10 per cent from these prices.

CUT-OUTS, PLUG

S. P. M. I.	$0.08	D. P. D. B.	$0.32
D. P. M. I.	.15	T. P. to D. P. S. B.	.18
T. P. M. I.	.23	T. P. S. B.	.29
D. P. S. B.	.17	T. P. D. B.	.47

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. I.	$0.40	$1 08	$1.35
T. P. M. I.	.57	1 50	1 95
D. P. S. B.	51	1 35	.....
T. P. S. B.	96	1 90	.....
D. P. D. B.	72	2.45	.....
T. P. D. B.	1 58	4 40	.....
T. P. to D. P. D. B.	1 06	3 10	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$13 10
No. 16 cotton twisted	16 50
No. 18 cotton parallel	16 00
No. 16 cotton parallel	20 15
No. 18 cotton reinforced heavy	22 85
No. 16 cotton reinforced heavy	27 40
No. 18 cotton reinforced light	17 50
No. 16 cotton reinforced light	23 90
No. 18 cotton Canvasite cord	16 50
No. 16 cotton Canvasite cord	19 35

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.20	3-amp. to 30-amp.,	100	$0.40
35-amp. to 60-amp.,	100	30	35-amp. to 60-amp.,	100	.60
65-amp. to 100-amp.,	50	2.90	65-amp. to 100-amp.,	50	1.50
110-amp. to 200-amp.,	25	3.00	110-amp. to 200-amp.,	25	2.50
225-amp. to 400-amp.,	25	5.60	225-amp. to 400-amp.,	25	5.50
425-amp. to 600-amp.,	10	5.50	450-amp. to 600-amp.,	10	8.00

Discount: Less 1-5th standard package, 50%; 1-5th to standard package, 55%; standard package, 65%.

RENEWABLE FUSES, ENCLOSED—

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50 ea.	$1.10 ea.	100	10
35 to 60-amp.	1.00 ea.	1.25 ea.	100	10
65 to 100-amp.	2.00 ea.	3.00 ea.	50	5
110 to 200-amp.	4.00 ea.	5.00 ea.	25	5
225 to 400-amp.	7.50 ea.	11.00 ea.	25	1
450 to 600-amp.	11.00 ea.	16.00 ea.	10	1
450 to 600-amp.	11.00 ea.	16.00 ea.	10	1

RENEWAL LINE FOR ABOVE FUSES—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0–30 ampere, standard package	$2 40
0–30 ampere, less than standard package	2.75

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.40	$0.45	100	75	$0.75	$0.80	50
15	.40	.45	100	100	1.10	1.20	24
25	.40	.45	100	150	1.55	1.65	24
40	.40	.45	100	200	2.10	2.25	24
50	.40	.45	100	300	3.15	3.35	24
60	.45	50	100				12
				500	4.60	4.85	12
				750	6.50	6.85	8
				1,000	7.50	7.85	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.19
Composition 2-piece attachment plug	.26
Swivel attachment plug	.12
Current taps	.36

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York.

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$ 6.75	$ 8.57	$10.64	$16.75
12	9.27	11.30	13.65	25.88
10	12.45	14.52	16.87	33.54
8	16.80	18.96	22.55	44.50
6	.....	.....	33.79	.....
4	.....	.....	45.51	.....
2	.....	.....	67.74	.....
1	.....	.....	89.26	.....
0	.....	.....	106.68	.....
00	.....	.....	126.92	.....
000	.....	.....	153.64	.....
0000	.....	.....	183.84	.....

SOCKETS, BRASS SHELL—

⅛ In. or Pendant Cap Key Each	Keyless Each	Pull Each	¼ In. Cap Key Each	Keyless Each	Pull Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package	15%
1-5th to standard package	30%
Standard package	45%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B. & S. regular spools (approx. 8 lb.)	34c. lb.
No. 18 B. & S. regular 1-lb. coils	35c lb

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb
Rubber tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb.
Wire solder, less 100 lb. 27c. lb., 100 lb. lots	21c. lb
Soldering paste, 2 oz. cans	$1.00 doz.

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$0.42	$0.68	$1.02	$1.36
60	.74	1.22	1.84	2.44
100	1.50	2.50	3.76	5.00
200	2.70	4.50	6.76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

30	70	1.06	1 60	2.12
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7.30
200	4.40	6.76	10.14	13.50

Discounts

Less than $10.00 list value	5%
$10 to $25 list value	20%
$25 to $50 list value	25%
$50 to $200 list value	35%
$200 list value or over	40%